THE ANIMAL KINGDOM.

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THE

ANIMAL KINGDOM,

CONSIDERED

ANATOMICALLY, PHYSICALLY, AND PHILOSOPHICALLY.

BY

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TRANSLATED FROM THE LATIN

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VOLUME II.

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"EO PROVECTI SUMUS UT HODIE AURIS ET OCULI SENSATIONEM VALDE SUPRA SEIPSAM, AUT SUPRA NATURALE SUUM ACUMEN, PER ARTIFICIALIA ORGANA EXALTARE SCIAMUS: JAM SUPEREST, UT ETIAM MENTEM, SEU AUDITUM ET VISUM RATIONALEM."—SWEDENBORG, ŒCONOMIA REGNI ANIMALIS, TR. II., N. 207.

"COGITATIO EX OCULO OCCLUDIT INTELLECTUM, AT COGITATIO EX INTELLECTU APERIT OCULUM."—SWEDENBORG, SAPIENTIA ANGELICA DE DIVINO AMORE, N. 46.

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TRANSLATOR'S PREFACE TO PARTS II. AND III.

In presenting to the public the concluding volume of the "Animal Kingdom," the translator has but little to add to what was specified in the Preface to Part I. The same principles have now guided him throughout in the translation of the whole work; the same care has been used in verifying the citations from the old anatomists, and in correcting the references with which the work abounds. In Parts II. and III. the whole of the citations, not excepting those from Winslow, are in fact translated from the original sources.

In making a quotation, Swedenborg sometimes only gives an abstract of the passage he professes to cite; sometimes he gives in his own words the sense of the author; and this, not seldom very imperfectly. In all such cases one rule has been obeyed; viz., to follow the original works *verbatim*, and if an additional length of quotation is necessary to the sense, to make it without reserve. In no instance, however, has a passage been shortened, or anything omitted of which Swedenborg has given an indication.

An Index of Authors is appended; also a short series of Bibliographical Notices of those authors who especially furnish the anatomical basis of the work. In preparing the Index of Subjects, the model furnished by Swedenborg himself in his ad-

mirable index to the "Arcana Cœlestia," has been imitated as far as possible. This Index of Subjects, it is hoped, will be found not unreadable in a connected form; in which case the perusal of it will furnish a good introduction to the study of the work itself. Lastly, the translator has had great pleasure in inserting the learned Memoir on Swedenborg's Physiological Manuscripts, which was kindly sent to him, in Latin, through the celebrated Baron Berzelius, by Dr. J. E. Svedbom, Librarian to the Royal Academy of Sciences of Stockholm. He trusts that this Memoir will incite the admirers of Swedenborg's works to secure the publication of his MSS., and first, perhaps, of that on the "Cerebrum," which would have constituted Part IV. of the "Animal Kingdom," had Swedenborg continued his labors in the field of science.

The Introductory Remarks, which are intended for insertion in Volume I., will, the translator hopes, be of some assistance to those who have the best title to expect it, and at the same time to any scientific reader who is desirous of perusing a slight outline of Swedenborg's physiological doctrines.

The idea of giving a glossary of obsolete terms has been abandoned. Any old medical dictionary will supply all that could be desired in this respect. It will be for the readers of Swedenborg to consider, whether his physiological works shall not be illustrated with an Atlas of Plates from the old anatomists: but this can better be settled when the whole of those works are in print.

It remains for the translator to make his profound acknowledgments to those numerous friends who have supported him in the publication of the "Animal Kingdom," and through whose generous patronage the first volume is now out of print.

13, Store Street, Bedford Square, London,
Sept. 16, 1844.

THE

ANIMAL KINGDOM,

CONSIDERED

ANATOMICALLY, PHYSICALLY, AND PHILOSOPHICALLY.

PART II.

THE VISCERA OF THE THORAX, OR THE ORGANS OF THE SUPERIOR REGION.

THE ANIMAL KINGDOM.

PART II.

CHAPTER I.

THE NOSE AND THE UVULA.

335. HEISTER. "The nose is the organ of smell. This part varies greatly in size and figure in different subjects; it may be either middling, very large or very small; either handsome or the reverse, or aquiline, flat, or depressed. Anatomists divide its parts into external and internal: to the former class belong the dorsum, the root, the bridge, the point, and the alæ or pinnæ; the septum dividing the nose into two cavities, termed nares or nostrils; the hairs, called by some vibrissæ, which prevent the involuntary discharge of mucus, and the entrance of insects into the fauces; the common teguments, epidermis, skin, and fat. The upper part of the nose is rigid, and composed of bones; the lower part is flexible, and made up of a number of cartilages, muscles, and membranes. The internal parts are the bones, several of which concur to produce the structure of the nose; as the nasal, maxillary, ethmoid or cribriform, spongy, frontal, lacrymal and palatine bones, the vomer, and the sphenoid bone. The cartilages, which form the lower part of the nose, are connected by membranes, in order that the nose may be flexible in that part. The first of these cartilages constitutes the anterior part of the septum narium; there are also two very considerable cartilages in each of the alæ, and between these there are placed sometimes two, sometimes three, and sometimes more, of smaller size. The septum narium is cartilaginous in its anterior and lower part, but osseous in its posterior and upper part; and these parts are connected by strong membranes. There are two passages from the nostrils into the mouth, designed for the passage of air

and mucus. There are also sinuses in the maxillary, frontal, and sphenoid bones, and cells in the ethmoid bone; all of which increase the nasal cavity, and thus allow of an additional expansion of the pituitary membrane, and augment the sense of smell. There are besides certain inequalities and prominences of the turbinated or spongy bones in the cavity of the nares; serving partly for the same purposes, and partly for preventing the passage of insects and cold air into the fauces.

336. "The nostrils and all the sinuses and inequalities are invested by a soft, red, and vascular membrane, termed the mucous, pituitary, or Schneiderian membrane, which is the organ of smelling and the place of secretion of the mucus of the nostrils. The oscula or orifices of the excretory ducts are very conspicuous on this membrane, especially in the head of the ox. Under the membrane we observe a number of little glands, particularly about the middle septum; these also are designed for the secretion of mucus. The arteries which are distributed in prodigious numbers through this membrane, arise from the carotids, and these too serve for the same secretion. The veins are from the jugulars, and are intended to return the superabundant blood of the part. The nerves distributed through the pituitary membrane, are, 1. The olfactory nerves, which are of considerable size, yet not so large as in the lower animals; these are supposed to constitute the organ of smell. 2. Some branches of the fifth pair, which terminate in the hairs or villi, and are thought by others to perform the sensorial office. Under the pituitary lies a thin membrane, which lines the bones and cartilages, and which, where it invests the latter, is termed perichondrium; where the former, periosteum. The foramina in the nostrils are, 1. Those of the frontal, maxillary, and sphenoidal sinuses, and of the cells of the ethmoid bone, serving for the communication of these sinuses and cells with the nostrils. 2. The orifices of the lacrymal ducts, opening into the nostrils on both sides; these are excellently figured by Morgagni. 3. The ducts from the two nostrils to the mouth [palate]; these are open in the skeleton, and may be seen just behind the incisor teeth of the upper jaw; but they do not open thither in either the living or dead subject, but are accurately closed by the membrane of the palate; wherefore the common opinion, that they transmit mucus from the nostrils into the mouth, appears to be erroneous. (*Comp. Anat.*, n. 286.) In my last dissections I have taken considerable pains to search for what are termed the ducts of Steno, running from the nostrils to the palate, behind the incisor teeth; but in proportion as they are manifest in the skeleton, in the same proportion they seem to be obscure in the fresh subject. I have always indeed found a

number of rugæ and depressions behind the incisor teeth; but I could never, either by means of a bristle or of the finest style, such as easily enters the puncta lacrymalia, make out any duct or canal running thence to the nose. After removing the corrugated membrane of the palate in this place, the style entered for a short way into an osseous canal, along the membrane which runs through this canal, but it did not penetrate into the nose. And on the other hand, the attempt to find a passage from the nose into the mouth was equally fruitless; not even the finest style or bristle could make its way. On these accounts, I suspect that this latter membrane, which is very strong, is in reality a ligament, serving to strengthen the membrane of the palate, and connect it to the bone, and thus to prevent it from being separated therefrom by hard and rough food, and other sources of injury; which, if this were not the case, might give rise to very serious consequences. (*Ibid.*, not. 59.)

337. "The ethmoid, or cribriform bone, is the eighth bone of the cranium. The points which it presents for notice, are, its situation; its extension through the nostrils and orbits; its figure, its connexion, and its state in infants; its four apophyses,—the crista galli, the upper part of the septum narium, and the two superior spongy, or, as they are also called, turbinated bones, to which Morgagni has added two other smaller spongy bones; the cribriform, the cavernous, papyraceous or plane part; and under this, the various little sinuses, differing in figure, size and number in different subjects. (*Ibid.*, n. 72.)

338. "The muscles of the nose are three pair: two pair of dilators, and one pair of constrictors. The dilators, which serve also to elevate the nose, vary greatly in different subjects; generally however there are two on each side, although they are often extremely small: these are termed the pyramidalis and myrtiformis. The pyramidalis arises from the root of the nose, and is usually continuous with the frontalis; it descends for a short distance at the side of the nose, and gradually expanding into a thin membrane, is inserted into the alæ nasi: it often sends down fibres as far as the upper lip. The myrtiformis, or dilator, strictly so called, arises near the incisorius of the upper lip, of which it frequently is but a portion, and is inserted partly into the alæ nasi, and partly into the upper lip. The constrictor, which is not orbicular in the human subject as it is in various animals, is only a small muscle: it was first described by Cowper, although figured by Eustachius: it arises above the incisor teeth of the upper jaw, and terminates in the alæ nasi. Santorinus endeavors to shew that it is double, which I have also observed occasionally myself; the orbicular muscle of the lips greatly assists its action. (*Ibid.*, n. 320.)

B 2

339. "The uvula, called by Celsus, uva, by others columella, is a body of a cylindrical, or rather of an inverted conical figure, situated in the back part of the palate, above the root of the tongue, between the two arches of the palate and the two tonsils, and hanging from the velum or claustrum palati. In figure it bears a considerable resemblance to the last joint of an infant's finger. Its substance is muscular, surrounded by the glandular membrane of the mouth. It has two membranous ligaments, by which it is connected to the bones of the palate. It does not exist in the lower animals. *(Ibid.*, n. 283.) The muscles of the uvula are six pairs, and one single muscle. 1. The glosso-staphilinus, or glosso-palatinus, arises on each side from the root of the tongue, ascends towards the palate, and terminates in the velum 2. The pharyngo-staphilinus arises on each side from the lateral portions of the pharynx, and terminates also in the velum. 3. The thyro-staphilinus arises from the lateral part of the thyroid cartilage, becomes broader as it ascends towards the uvula, and is inserted in the manner of an arch into the side of the velum. 4. The spheno-staphilinus of Cowper, Cant, and others, may be more correctly termed the salpingo-staphilinus; for in my last investigations, I have found that it arises in no degree, or at any rate to a very small extent, from the sphenoid bone, but rather from the posterior part of the tube, and, in fact, partly from its membranous, partly from its osseous portion; thence it descends obliquely to the uvula, and is inserted into its posterior part: hence, if both these muscles act together, they retract the uvula. 5. The pterygo-staphilinus arises from the upper part of the pterygoid process, and from the anterior part of the tube which is near it; descends between the two lamellæ of the former, and reflects its tendon over the thin apophysis of the interior lamella, as over a kind of pulley, to the anterior part of the palatine membrane, into which it is inserted: the uvula is, therefore, moved downwards and forwards by this pair. Valsalva calls this the new muscle of the tube, although its existence has long been known: he supposes that its office is to dilate the tube. 6. The palato-staphilinus arises on each side, at the junction of the bones of the palate; it is broad at its beginning, but after joining its fellow muscle it becomes gradually narrower, so as to resemble a triangle, and descends to be inserted into the upper part of the uvula: its action seems to be to draw the uvula upwards and forwards. 7. The azygos of Morgagni, placed at the back of the last pair, seems to arise tendinous from the junction of the bones of the palate, and is extended fleshy, but thin and round, through the middle of the uvula; for with the glands and membrane of the mouth, it constitutes the body of the part." *(Ibid.*, n. 326.)

340. WINSLOW. "The septum of the nose is formed by the descending lamina of the ethmoid bone, and by the vomer, and it is placed in the groove or channel formed by the cristæ of the maxillary bones and edges of the palate bones. The dorsum of the osseous part of the nose is formed by the true nasal bones; and the sides, by the superior or nasal apophyses of the maxillary bones. The internal nares, or the two cavities of the nose, comprise the whole of the space between the external and posterior nares, immediately above the arch of the palate; from whence these cavities reach upwards as far as the cribriform plate of the ethmoid bone, where they communicate in front with the frontal sinuses, and behind with the sphenoidal sinuses. Laterally, these cavities are bounded on the inside by the septum narium, and on the outside, or that next the cheeks, by the conchæ, between which they communicate with the maxillary sinuses. The particular situation of these cavities deserves our attention: the bottom of them runs directly from before backward, so that a straight and pretty large stilet may very easily be passed direct from the tip of the nose, as far as under the great apophysis of the occipital bone. . . . The inferior portion of the external nose is composed of several cartilages, which are commonly five in number, and of a pretty regular figure; the rest are only accessories, smaller, more irregular, and the number of them more uncertain. Of the five ordinary cartilages one is situated in the middle, the other four laterally. The middle cartilage is the principal, and supports the rest. It is connected immediately to the bony parts; the other four are connected to the middle cartilage and to each other by means of ligaments. The principal or great cartilage of the nose is divided into three parts, one middle and two lateral. The middle is a large cartilaginous lamina, joined by a kind of symphysis to the anterior edge of the middle lamina of the ethmoid bone, to the anterior edge of the vomer, and to the anterior part of the groove formed by the maxillary bones, as far as the nasal spine of these bones, and the extremity of the sub-septum. This lamina completes the septum, and indeed forms the principal part thereof. . . . All this apparatus of the external nose is covered by the common integuments, the skin, epidermis, and fat. That which covers the tip of the nose and alæ narium, encloses a quantity of glandular granules, the sebaceous glands of Morgagni, the matter of which may be easily squeezed out by pressure with the nails. All the bony and cartilaginous parts have likewise their periosteum and perichondrium. . . . The pituitary membrane is that which lines the internal nares, the cellular convolutions, the conchæ, the walls of the septum, and by an uninterrupted continuation, the inner surface of the frontal and maxil-

lary sinuses, and of the ductus lacrymales, palatini and sphenoidales: it is likewise continued further, from the posterior nares to the pharynx, septum palati, &c. It is termed pituitary, because in the greater part of its extent it serves to separate from the arterial blood a mucilaginous lymph, called pituita by the ancients; and which in the natural state is pretty liquid, but otherwise is glutinous and viscid, or sometimes limpid and without consistence, or exhibits other changes; it is not supplied in equal quantities by the whole membrane. When we carefully examine this membrane, it appears to be of a different structure in different parts. Near the edge of the external nares it is very thin, like skin and epidermis in a degenerated state: through the rest of its extent it is in general spongy, and more or less thick. The thickest parts are on the parietes of the septum narium, on the whole lower portion of the internal nares, and on the conchæ. If we make a small opening in it with the point of a scalpel in any of these places, and use the blow-pipe, we discover a very extensive cellular substance. It appears to be of a more slender texture in the sinuses. On the side next the periosteum or perichondrium, which it accompanies, it is covered with glandular granules, the excretory ducts of which are very long near the septum narium, and their orifices very visible; and by applying a blow-pipe to any of these orifices, the ducts may be inflated through nearly their whole extent: but in order to this, the parts must first be well cleaned and washed in warm water. In these places especially, we likewise discover a fine villous substance; but it is not seen unless the parts be examined in clear water, in the manner which I have used in my public courses for above twenty years past. The frontal, sphenoidal, and maxillary sinuses all open into the internal nares, but in different ways. The frontal sinuses open from above downwards, answering to the infundibula of the ethmoid bone. The sphenoidal sinuses open forwards, opposite to the posterior nares. The maxillary sinuses open a little higher, between the two conchæ. . . . The opening of the maxillary sinuses, which in some subjects is single, in others double, lies exactly between the two conchæ, about the middle of the depth of the maxillary cavities. . . . It is proper here to observe exactly the extent of the maxillary sinus: below, there is a very thin partition between it and the last four molar teeth, the roots of which in some subjects penetrate the sinus in this situation. Above, there is only a very thin transparent lamina between the orbit and the sinus. Behind, above the tuberosity of the maxillary bone, the side of the sinus is also very thin, particularly in front of the root of the pterygoid process, through which the inferior maxillary nerve sends down a branch, that descends towards the posterior palatine, or gustatory foramen. The lacrymal sac

is a small oblong membranous bag, which receives the serosity of the eye through the puncta lacrymalia, and discharges itself below into the internal nares. It is situated in part in an osseous canal formed by the nasal apophysis of the maxillary bone and os unguis; in part also in an osseous canal formed in the same maxillary bone, &c. . . . This sac is somewhat spongy or cellular, and moderately thick. It is strongly united by its convex side to the periosteum of the bony canal. . . . It appears to be composed of two laminæ, joined together by a spongy substance: the internal lamina seems to be glandular. The ductus incisorii, or naso-palatine ducts of Steno, are two canals which extend from the bottom of the internal nares across the arch of the palate, and open behind the first or largest incisor teeth. Their orifices may be seen distinctly in the skeleton: and we may likewise observe their oblique passage through the maxillary bones, and lastly their inferior orifices, situated in a small cavity or fossula, termed the anterior palatine foramen, &c. . . . The arteries of all these parts come from the external carotid. Those of the external parts of the nose are chiefly branches and ramifications of the external maxillary or angular, and of the temporal arteries; and the arteries of the internal parts are chiefly branches and ramifications of the internal maxillary artery. The veins, in almost the same manner, are the corresponding branches and ramifications of the external jugular vein. They communicate with the orbital sinuses, and by that means with the sinuses of the dura mater, and ultimately with the internal jugular veins. The principal nerves belonging to the nose are filaments of the olfactories, which pass through the foramina in the transverse plate of the ethmoid bone, and are distributed to the common membrane of the internal nares, especially to the villous portions thereof. The internal branch of the orbital or ophthalmic nerve sends a filament through the small internal anterior orbital foramen into the cranium, which comes out again in company with one of the above-mentioned filaments, through the ethmoidal lamina. This internal branch afterwards advances towards the os unguis, and is distributed partly to the lacrymal sac, partly to the upper portion of the pyramidalis muscle, and of the integuments of the nose. The suborbital nerve, which is a branch of the superior maxillary nerve, having passed through the inferior orbital foramen, transmits filaments to the external lateral parts of the nose; another branch of the superior maxillary nerve goes to the posterior nares of the same side, and is spent on the conchæ and other internal parts of the nose. (*Exp. Anat., Traité de la Teste,* n. 319—359.)

341. "The claustrum, which may likewise be termed velum, or valvula palati, terminates below by a loose, floating border, represent-

ing an arch, situated transversely above the base or root of the tongue. The highest portion or top of this arch supports a small, soft, and irregularly conical, glandular body, the base of which is attached to the arch, and the apex hangs freely downwards; this body is commonly called uvula. The pillars or columns of the claustrum are four muscular half-arches, two on each side of the uvula, to which the upper extremities of them all are united. They are so disposed, as that the lower extremities of the two which lie on the same side are a little separated from each other, the one being anterior, the other posterior, and they leave between them an oblong triangular space, the apex of which is at the base of the uvula. The two half-arches on one side, by joining their fellows on the other side, form the entire arch of the border of the claustrum. The posterior half-arches run, by their superior extremities, more directly towards the body of the uvula, than the anterior. The anterior half-arches are continued to the sides of the base of the tongue, and the posterior to the sides of the pharynx. In the lower part of the space left between the lateral half-arches on the same side, are situated two glandular bodies termed amygdalæ." *(Ibid.*, n. 489—491.)

342. For the rest, see Boerhaave, on smelling, *Inst. Med.*, n. 491—507; on the action of the uvula, *Ibid.*, n. 70, 71. Winslow, on the ethmoid bone, *Tr. des Os Secs*, n. 241—254; on the proper bones of the nose, *Ibid.*, n. 396—403; on the inferior conchæ, *Ibid.*, n. 435—446; on the muscles of the external nose, *Tr. de la Teste*, n. 329—333. Morgagni, *Advers. Anat.* vi., tab. ii., fig 3: where the turbinated bones of the nares are beautifully portrayed, and it is shewn that they are three in number, the ossa turbinata inferiora, superiora, and suprema, the latter being the smallest: and *(Ibid.*, Anim. 53,) that these bones are double, each nasal antrum containing a set: and *(Ibid.*, Anim. 89,) that whatever be the position of the body, mucus flows from some of the nasal cavities. Eustachius, *Tabul. Anat.*, tab. xi., fig. 16, and tab. xviii., fig. 1; representing the frontal muscles, the constrictores palpebræ, and orbiculares labiorum; and the manner of their operation on the dorsum and alæ of the nose. Tab. xv., fig. 1; tab. xiii., fig. 2, *a*; the left pyramidalis muscle serving to dilate the alæ. Tab. xviii., fig. 3, *a*; the proper semilunar muscle [depressor pinnæ] of the nose. Tab. xx., fig. 1, 3, 4, 5; the nasal bones in the skeleton. Fig. 14, 16; the cribriform bone, displaying the foramina through which the olfactory nerves pass out, and through which, according to Lancisi, they also receive something from the external nares. Ruysch, on the mucous membrane, its arteries and glands, *Thes. Anat.* ii., iii., vi., x.; *Epist.* viii., ix., *passim*; and his tabulæ. Verheyen, *Corp. Hum.*

Anat., tract. iv., cap, xv., tab. xxviii., fig. 4, 5; the cartilages of the nose, including the three lesser cartilages, and which amount in all, according to Ruysch, to nine in number. Fig. 6, the same. Fig. 8, 9; the cavities of the frontal, ethmoid, and sphenoid bones; exhibiting a number of vesicles produced by inflation, respecting which, see the same author, *Ibid.*, tract. iv., cap. xvi. Cowper, *Myotom. Ref.* (8vo., London, 1694), p. 57; and *Anatomy*, App., tab. ii., fig. 35; representing the muscles of the nose. Mangetus, *Theatr. Anat.*, tab. x., fig. 2, from Brown; representing the constrictor nasi, elevator, and corrugator muscles. Tab. xii., fig. 2, also from Brown; the gland of the palate, with the uvula reflected upwards. Tab. cviii., from Bidloo; the interiors of the palate together with the uvula. Fig. 2, from the same; the superior concave part of the mouth and the [naso-palatine] duct of Steno. See also many plates from Ruysch, inserted in the same collection. Palfin, *Nouvelle Osteologie*, pl. i., ii. Drake, *Anthropologia Nova*, tab. xvii., xviii. Highmore, *Corp. Hum. Disquisit. Anat.*, and his tabulæ. Santorinus, *Observationes Anatomicæ*, cap. i., n. 9, where he ascribes eight pairs of muscles to the nose. Vieussens, *Neurographia Universalis*, lib. i., cap. xvi., treating of the aqueous and emissary ducts of the head, and of the pituitary membrane.

ANALYSIS.

343. As there is a high road from the labial entrance, through the fauces and œsophagus, to the viscera of the abdomen (*a*), so there is a high road from the two entrances of the nares, through the trachea, into the lungs, which fill the chamber of the breast, or the cavity of the thorax. From these entrances, then, as the natural beginnings, we commence to speak of the viscera of this region; but adhering to the law laid down in the first instance, we must make our exordium from use (*b*). The nares, divided from each other by a septum or partition, articulated by cartilages, fortified by bones, covered in by membranes,—with their alæ, point, spine, dorsum, and root or brow,—I. Open the way, and allow the lungs the possibility of respiring; for they are the first doors or gates through

(*a*) That the way to the stomach, consequently to the viscera of the abdomen, leads from the mouth through the pharynx and œsophagus, see Part I., n. 59. There are then two entrances in the head, namely, the orifice of the lips, and that of the nares; the first leading to the lowest region of the body; the second, to its middle region, that is, to the thorax. In man, indeed, the labial orifice conducts also into the thorax, and to the lungs; for we respire through the mouth as well as through the nares; but the case is different in brutes, for with them, the nasal passages are blocked up, and all respiration that way is intercepted. The reason why in man the labial orifice is common to both regions, will be pointed out in the sequel. But the tongue, which is the motory organ of the palate, and of the whole apparatus of the mouth, is common to both, because it serves for both eating and speech; and this is the reason why we began our disquisitions with the tongue.

(*b*) See Part I., n. 32.

which the breathings of this living world are carried to and fro. They temper with a gentle warmth the air which is entering; and impregnate with a dewy vapor the air which is departing; and cleanse and purify it from floating particles of dust, and noxious exhalations. II. They anticipate by the sense of smell, what the atmosphere of the circumambient world carries in its bosom, so as to make the animal being aware of that which is endeavoring to rush inwards into its lungs. III. By a kind of unison, they regulate the articulate sounds of speech, and to a certain degree, as it were by provisional alæ, conspire to modify the words themselves. IV. They clear away the viscid phlegm from the arteries, in order that a pure and clean blood may ascend to the sensoria of the cerebrum, and to the other sensoria of the head. Furthermore, they derive from all these organs the ichorous streams that threaten inundation; that is to say, from the eye and the ear, from the medullary and cortical portions of the cerebrum, from its meninges or membranes, and from the sinuses of the cranium. V. By an extrinsically impulsive force, they excite the cerebrum to its proper reciprocal animations, synchronous with the respirations of the lungs. VI. Like a kind of cynosure, they terminate and complete the common axis of the hemispheres of the cerebrum, and of its parts, as well as of the bones of the cranial vault; and they institute and begin the common axis which runs from thence into the thorax, as well as that which runs into the abdomen. VII. Thus, from the ultimate boundary of this axis, they transcribe the cerebrum into the face, and give it the power of imaging its affections upon the surface or countenance thereof. We shall now proceed to consider each of these uses separately.

344. I. *The nasal entrances open the way, and allow the lungs the possibility of respiring.* This proposition is obvious and universally admitted; for through these causeways or breathing-holes the atmospheric world flows in, but through the others, which like the nares are sensoria, only the nature or properties of that world (*c*). The influent atmosphere, however, is instan-

(*c*) Through this way alone, that is to say, through the larynx and the trachea, that world, or the atmosphere thereof, flows in substantially; but it does not long remain within, being immediately thrown

taneously expelled, lest it should claim power over a little world not belonging to it; indeed it is admitted only as a convenient servant. For this reason, the innermost spiracles or breathing-holes,—the pulmonary vesicles,—open first (*d*); afterwards the bronchia, beginning at their roots; then the trachea and the glottis; lastly the nares, all the way to the alæ or pinnæ, which are dilated by their muscles: thus the air is admitted, invited and attracted; and flows in, as in a bellows at work, according to the given opening, the height of the incumbent column, and the force of gravity dependent thereupon (*e*). *The nares temper with a gentle warmth the air which is entering;* and as on the one hand they prevent the cold, or the biting winter, from injuring the lungs, and their pneumatic principles or initiaments, and contracting them more rapidly than their reciprocal alternations demand; so on the other hand they provide a bland temperature that will constantly further their respirations, and bathe and

out by expiration; so that according to our often-repeated assertion in Part I., the animal kingdom exempts itself universally from the rule and domination of the circumambient world, and is governed purely by the laws and principles existing in itself. See Part I., the Chapter on the Intestines. Consequently the air does not rush in unbidden, but is admitted, allured and attracted, as every one may clearly observe in his own person. Moreover, immediately on its entrance it is subjugated in such a manner, that it is not at its own disposal, and does not act with all its gravity, but is derived into the lungs, both with respect to its quantity and with respect to its direction, at their will and pleasure. The other sensorial organs, as the eye and ear, admit the atmospheres, indeed, but only the modifications thereof, by which nature manifests herself and her modes of forces.

(*d*) This will be explained more fully in the Chapter on the Lungs.

(*e*) In the Chapters on the Liver, the Pancreas and the Spleen, it was shewn, that the blood is not intruded by force into their glandular principles, that is, into their minute follicles, but is invited by acts of expansion; precisely in the same manner as in the lungs. This produces a particular attraction resembling the attraction of bellows or pumps, in which latter the air rushes in to fill the void caused by raising the piston; so that the attraction is no property of the vacuum, but rather is nature's aversion to, and avoidance of, a vacuum, in consequence of which the matter near the scene of operation is continually urged to fill the vacant space.

foment the cribriform plate, and the delicate nerves issuing therefrom. To produce these results, the nasal canals decrease in size from the bottom to the top (*f*); and in the middle of their course, are reflected towards the palate and the larynx (*g*); while those which pass upwards are folded from below to above, twice or three times, into papyraceous convolutions or spirals (*h*);

(*f*) The largest aperture of the nares is that which is comprehended by the alæ nasi; the orifice becomes constantly narrower in passing upwards.

(*g*) Where the cartilages terminate, two passages commence on each side; one, leading upwards through the conchæ towards the cribriform plate; the other, passing obliquely downwards towards the palate and the glottis; but the two latter reflected passages again unite into one. "Each of the nares," says Verheyen, "is divided into two parts or cavities; one of which goes upwards to the cribriform bone; the other, which is much the longer, passes above the palate into the interiors of the fauces and mouth. . . . The latter on each side unites with its fellow in the palate, and the two constitute one cavity. . . . which in this situation is very large, and . . . placed directly above the fissure of the larynx" (*Corp. Hum. Anat.*, tract. iv., cap. xv). By virtue of this inflexion and of the warmth imparted by the superior region of the nares, the coldness of the air cannot fail to be broken and tempered, and the breath inhaled to be rendered mild and warm; as we have physical proofs to demonstrate; for if the very coldest air be passed through even a short tube that has been previously warmed, it instantly comes out warm at the other end; and the more in the narrow passages of the nares, where warmth is imparted by all the arteries, membranes, and constantly vibrating papyraceous bones.

(*h*) For there are three pairs of cochleæ, or as they are usually termed, turbinated and spongy bones, through which the air circulates in passing upwards; consequently none but warm air can possibly reach the cribriform plate of the ethmoid bone. On the way also, as the air runs through these gyres and whirls, it is examined, and purified of all noxious vehicles, fine dust, or heavy and misshapen particles, until nothing is left that can injure or offend the exquisitely delicate nerves in their beginnings. Morgagni has admirably delineated the three pairs of cochleæ, and describes them as "the ossa turbinata inferiora, superiora, and suprema, and that these bones are double, each nasal antrum containing a set" (n. 342). These triple cochleæ or conchæ are termed by Vieussens, the cells and sinuses of the ethmoid bone, and he like-

so that the air circulates in them exactly according to its natural fluxion (*i*), and never reaches the osseous sieve of the cribriform plate, until it has traversed various labyrinthine windings, and been warmed by a large extent of surface. Indeed, the organically constructed sinuses are so many correctives and prohibitives, whereby the air, or the blistering wind, is prevented from penetrating internally. *The nares impregnate with a dewy vapor the air which is departing,*—they set free the fine aqueous exhalation, leaving the mucus behind; as is sufficiently evident from the wateriness of the expirations. Lastly, *they cleanse and purify the air from floating particles of dust, and noxious exhalations.* This is the purpose of the vibrissæ or hairs; also of the membrane, perpetually moistened by so many lymphs from extraneous sources, and by so many proper to itself, and anointed with the viscid mucilage, left after the evaporation of the finer dew (*k*), so that it can ensnare irregular and misshapen corpuscules, and snatch them away from the air. This also is the reason why the organ has a power given it of contracting itself

wise divides them into three pairs, although some anatomists divide them only into two. "We reckon," says he, "six ethmoidal sinuses, intermediate between the frontal and sphenoidal sinuses, and which are separated from each other by true bony partitions: these six sinuses we divide into anterior, middle, and posterior" (*Neurogr. Univ.*, lib. i., cap. xvi.)

(*i*) That the air has a tendency to gyrate spirally, is abundantly proved by the phenomena of pneumatics, that is to say, by the phenomena both of aërial modification and of sound, and by the spiral cochleæ and semicircular cylinders in the organ of hearing: the same thing is also proved by the very nature of the air, of which we shall speak in another place.

(*k*) We shall have to shew presently, that there is a general derivation of humors hither, both from the sinuses of the cranium, and from the adjoining sensorial organs, nay, from the cerebrum itself, not to say, from the numberless arteries that supply the pituitary membrane. It also appears that the breath expired is absolutely filled with moisture, and as it only carries off the limpid and thin portion, the remainder is of course comparatively thick and viscid, and adapted for netting and catching the heavy effluvia that the air brings in. The thickness of the mucus may be accounted for in this way.

by means of muscles; by virtue of which construction it bears a resemblance to a kind of rude strainer, endowed at the same time with the faculty of smelling the substances that impinge upon it.

345. II. *The nares anticipate by the sense of smell, what the atmosphere of the circumambient world carries in its bosom*; that is to say, whatever is floating freely in the little volumes of the air, and is figured, angular, plane or smooth; round, extended or long; weighty and naturally inert (*l*); derived originally from the terrestrial kingdom, but afterwards exhaled from either the vegetable or the animal kingdom (*m*); whatever, conse-

(*l*) Those things, we mean, that float about in the air, and are so versatile as to be capable of applying themselves in the freest manner, by means of the air, to the little sensoria or papillæ, and of imprinting upon them, as perfectly as upon the most yielding wax, the complete figure of their sides, angles and planes; in the same way as the nutrient particles of the food imprint their figures upon the tongue, which particles, were they not dissolved and floated by the saliva, or some other extraneous liquid, could not possibly communicate any idea of their form, or we should rather say, of their figure. There are then three organs which receive sensations and sensuous distinctions from the contact of corpuscular bodies, to wit, the organs of touch, taste and smell; but the two other organs—the sensoria of hearing and sight—receive their sensations and distinctions from the mere modifications of the atmosphere. Although, however, the former derive their sensations from hard and diversely figured particles impinging upon them, nevertheless, those sensations are not the less modifications on this account; for the form imprinted upon the papillæ mounts up as a modification along the fibres towards the general sensorium. See n. 344 (*c*).

(*m*) All particles endowed with vis inertiæ or gravity come exclusively from the mineral kingdom; in fact, the earth is a collection of such substances and elements. But these particles pass from the bosom and womb of the earth, into vegetables, and thus from one kingdom into another; although in this case they are combined and disposed in a different manner,—into essential salts, juices, oils, spirits, resins, &c. From the vegetable kingdom they mount into our animal kingdom, as when we eat vegetables, or else they pass into the animals whose flesh we eat. Thus the parts of the mineral kingdom, suffering a transformation, come to be of use to man at last.

quently, is mineral, saline, or sulphureous; whether in fine it be called acid, alkali, nitre, spirit, oil, syrup, juice, or by any of the other infinite names of natural substances; provided only that it be raised upon the wings of the atmosphere, carried about, and adequate to the sensorial papillæ, and communicate exquisitely, by contact and application, all its points, angles and planes, or the entire figure of its sides, that is to say, its corpuscular form, to all points of the little sensorium. By virtue of an idea similar to the impression being excited and represented in the cerebrum, all over the termination of its fibres, or in the universal cortical substance, sense is produced (*n*), the affection of which sense is smell, either pleasant, sweet and fragrant, or unpleasant, rank and stinking; or mediate, with infinite variety, between these two extremes. To produce this affection, certain fibres, drawn from the whole of the medullary portion of the cerebrum, and collected into a bundle termed the mammillary process,—certain most delicate fibres,—soft, full, disposed fascicularly, encased in pia mater, proceeding to the cribriform plate of the crest of the ethmoid bone, and passing out, surrounded by dura mater, through its foramina (*o*),—

(*n*) In Part VII., treating of the Cerebrum, it is my intention to prove by many considerations, that all sensual modification creeping up along the fibres, terminates in the universal cortical substance,—the last and first boundary of the fibres; not mounting, as would most likely be our general impression at first sight, to those organic principles only that correspond to the fibres proceeding to the organ of sense; but mounting to the whole sensorium in common, this being what is affected.

(*o*) We shall treat of the olfactory nerves in the Part on the Cerebrum; but as we are here investigating the sense of smell, it seems to be necessary to give a short description of these nerves or processes, extracted from Vieussens, Ridley, Willis, and other anatomists; from which description we may be enabled in a summary to view the origin and derivation of this sensation. When the fore-part of the cerebrum is raised, the mammillary processes come in sight, together with the olfactory fibres proceeding from them. In man they are very thin and small, but in less perfect animals they are like two bottles, very large and nearly round, broad at their commencement, and decreasing by degrees, and they occupy a very considerable part of the fundus of the

thoroughly inseminate and distribute themselves through the pituitary or mucous membrane: by these are produced organic or villous forms, which are the little sensoria of this species of touch. From these preliminaries we may now conclude respecting the path by which the modes and radii of this sensation mount from these little organs to the common sensorium of the cerebrum,—we may conclude that they mount by way of the fibres, and at the same time by way of the two meninges, and thus meet in the middle and central cortical substance (*p*). To

cerebrum: and in animals, in the seal for instance, we find these processes to contain a cavity distended with limpid fluid, the inflation of which cavity by means of the blow-pipe, will cause the whole mass of the cerebrum to rise and swell up. But in man they are not hollow, nor is the common opinion correct, that there is a passage from them into the anterior ventricles of the cerebrum. They lie immediately but freely upon the dura mater, all the way from the clinoid processes to the ethmoid bone: they are pretty soft; and when they reach the cribriform plate of the crista galli, they transmit a vast number of filaments through its foramina into the cavities of the ethmoid bone and the cells underneath them. As they descend, they are invested with, and accompanied by, an equal number of little prolongations of the meninges of the cerebrum, and they proceed until they reach the pulpy membrane, in which, and in its follicles, but particularly in the papillary substance, they terminate. In man they are white; in sheep and many other animals they are of a light grey: in these [animals], twigs derived from the carotid follow them down to their divisions and delicate fibrillæ. They consist of medullary fibrillæ, some of which derive their origin extensively from the posterior and anterior lobes, and from the middle portion of the centrum ovale; some, more limitedly, only from the anterior and inferior part of the medulla oblongata, where lying obliquely and meeting each other, they appear finally to arise between the exterior and posterior lobes. Some authors maintain that their fibres arise from the corpora striata, and in this region receive filaments from the anterior lobes of the cerebrum. The fibres of these nerves are much stronger and more numerous in dogs than in the human subject.

(*p*) We shall treat of these subjects more fully in the Part on the Cerebrum. That the modes of sensation mount up by way of the fibres, is a proposition which no one can think of denying; for all sense flies into the cerebrum along the track of the fibres; and when

heighten this effect, from the most particular modes of touch up to the general sensation, a spacious membrane is spread out, and all the cavities, cells, convolutions, leaves and sinuses are amply and continuously covered by it, as well as by a fine periosteum and perichondrium (*q*); so that the little scattered sensuous

the nerves are divided, sense is annihilated; and when they are injured, sense is altered and perverted in exact proportion to the amount and state of the lesion. But this sensation also passes up by way of the meninges or membranes, that is to say, by way of the pia and dura mater; for in truth both these membranes accompany the fibres, or fasciculi of fibres, as they accompany the nerves [of other parts], all the way to the pituitary membrane; in a word, to the organic termini; and the dura mater likewise supplies them with little sheaths. "The fibrillæ of the olfactory nerves," says Vieussens, "are covered with pia and dura mater as they enter the nares" (*Neurogr. Univ.*, lib. iii., cap. ii.) And according to Winslow, "The dura mater gives off as many little sheaths as there are foramina in the cribriform plate" (*Exp. Anat.*, *Tr. de la Teste*, n. 22): and again he says, "At the same place, the dura mater sends off a number of sheaths, that invest and accompany the nervous filaments and their ramifications, on the internal parts of the nose" (*Ibid.*, n. 134). Inasmuch then as every tremble, that is, every transcendent vibration, such as comes under the title of modification, pervades subtle fluid parts and contiguous soft parts, or passes along and runs over every continuum, therefore the contact or subtle impetus made upon the organic papillæ and their membranes, cannot possibly cease before it arrives in ultimates; consequently, passing at once from the fibres and the two meninges, it must go on until it arrives in the cortical portion of the cerebrum; in which, therefore, a meeting takes place, as in a most multiple common centre.

(*q*) Our authors shew throughout, that the pituitary membrane invests not only the larger cavities of the nares, but also the cells and conchæ of their superior chamber, and the frontal, sphenoidal and maxillary sinuses, and that it extends into the palate, the pharynx and the trachea. "The pituitary membrane," says Winslow, "is that which lines the internal nares, the cellular convolutions, the conchæ, the walls of the septum, and by an uninterrupted continuation, the inner surface of the frontal and maxillary sinuses, and of the ductus lacrymales, palatini and sphenoidales: it is likewise continued farther, from the posterior nares to the pharynx, septum palati," &c.

modes of singulars, collected into a common idea, at length emerge, in the form of evident sense, to our measure of perception and sphere of consciousness. And furthermore, with the same object, the very osseous laminæ themselves, thus covered, are convoluted into spirals and little vortices, in triple order, decreasing in size from below to above, or from without to within, exactly in accordance to the form of nature, considered as a modifying power (*r*); and by these vortices the straggling modes are drawn together, before they are diffused as one into the cerebrum. And in order that a nerve may be present, to announce with extreme and almost instantaneous rapidity the state of this sense to the moving or muscular fibres, and dispose them to suitable action, a branch is sent thither from the fifth pair (*s*). *By these provisions the animal being is made aware of*

(n. 340.) Vieussens traces it over the pharynx and larynx (*Neurogr. Univ.*, lib. i., cap. xvi.); so that it would seem to be continued, by the membrane of the bronchia, to the innermost parts of the lungs. Since then this membrane is so extensive, and contains not only glands, but papillæ, therefore, of necessity, the most particular forces, actions and modifications, must pass into it as a common membrane; and thus all accidents must be communicated to all the papillæ that are associated in the same function; precisely according to our declaration in Part I., Chap. I., where we treated of the Tongue. Wherever there is a particular, there also there is a corresponding general; for without a general or common modification, neither touch, nor any mode of a part or parts, from whatever cause arising, could come to evident sensation. Common or general modes are the only modes by which we are affected, and these we perceive in some measure distinctly; but individual or singular modes we perceive very indistinctly, or so subtly and finely that they appear to be nonentities; myriads of such require to be associated together, to present a single modulus or little mode which reaches our consciousness.

(*r*) See above, n. 332, note (*r*). Respecting the cells and conchæ of the upper part of the nose, termed by Winslow, the labyrinth, see that author's *Exp. Anat.*, *Tr. des Os Secs*, n. 247; and respecting the inferior conchæ, see *Ibid.*, n. 435—446.

(*s*) Besides the proper branches of the olfactory nerves supplied to the organ of smell, some authors attribute to it also certain branches from the fifth and sixth pairs of nerves. With respect to the fifth pair, Winslow says, "The internal branch of the orbital or ophthalmic nerve

that which is endeavoring to rush inwards into its lungs. This is still more exquisitely the case in those creatures that do not live under the guidance of a mind endowed with a proper intellect and will, but under the guidance of nature alone (*t*). Wherefore, in order that the nares may attract pleasing odors more fully and intimately, and remove fetid odors more completely, from the lungs and the cerebrum, certain muscles are provided, which either expand or contract the orifices and passages (*u*), and dispose them to every state of sensation.

sends a filament through the small internal anterior orbital foramen into the cranium, which comes out again in company with one of the above-mentioned filaments [of the olfactory nerves], through the ethmoidal lamina. This internal branch afterwards advances towards the os unguis, and is distributed partly to the lacrymal sac, partly to the upper portion of the pyramidalis muscle, and of the integuments of the nose," &c. (n. 340.) The same thing seems to occur here as we before remarked in the organ of taste, the tongue, to which also a little branch is supplied from the fifth pair; with the view, it would appear, that sense may make instantaneous common cause with motion; for the fifth pair is in a manner a common regulator and messenger,—the Mercury of the Olympus of the head.

(*t*) On this account, animals impelled by instinct alone or nature alone, have larger olfactory nerves than man, communicating also more intimately with the whole substance of the cerebrum, as appears from manifold experience in both birds and quadrupeds. We all know perfectly well the power of smelling possessed by dogs. Indeed, these and similar animals seem not only to have a keen sense of the particles floating about, as effluvia, in the gross air, but also to discern the purer distinctions of particles, and the things which are circulating in the subtler atmosphere of the ether: for smell alone is sufficient to shew them, whether the meat or food offered them, is suited to their nature or not. But we shall speak further of these points in the Part on the External Sensoria.

(*u*) Vieussens sometimes makes mention of muscular fibres as existing in the pituitary membrane itself, within the cavity of the nares (*Neurogr. Univ.*, lib. i., cap. xvi.); and which, if they do exist, are perhaps continuations from the velum palati. But the external muscles, by means of the contraction of the pinnæ and cartilages, are quite sufficient to prohibit the influx of injurious air. Besides which, we have the power of stopping our nostrils with our fingers; of suspending

346. III. *By a kind of unison, the nares regulate the articulate sounds of speech, and to a certain degree, as it were by provisional alæ, conspire to modify the words themselves.* For the sound emitted by the glottis, and taken up and circumscribed, under the direction of the tongue, by the velum palati, and shaped according to the boundaries of each portion thereof, speaking generally is carried out along the hollow arch of the mouth, through the opening of the lips; and equally also escapes through the path of expiration, or the nasal openings; this gives rise to a compound sonorous modification of the voice, which contributes to the sharpness, definition, and unison of the very sound; and also confers upon it that infinite variety which belongs to all things. We may learn the particular nature of this sharpness or discrimination, when the alæ of the nose are compressed or dilated, either artificially or naturally; when the passages are obstructed by stagnant or catarrhal mucus; or when we meet with individuals, who either on account of national peculiarity or acquired habit, speak more or less through the nares, and accompany the voice uttered by the mouth with a nasal sound. For the tremulous vibration of sound runs over and strikes all membranous, cartilaginous and osseous, and more especially all elastic parts, with wonderful velocity and continuity (*x*): thus it sweeps uninterruptedly over the pituitary membrane, from the very larynx, all the way to the foliaceous ossicles of the nose, and carries them into a similar but higher vibration, according to their spring, form, and mass; hence we have a compound modification in accordance with the structure of the labyrinthine recess of the nares.

347. IV. *The nares clear away the viscid phlegm from the arteries, in order that a pure and clean blood may ascend to the sensoria of the cerebrum, and to the other sensoria of the head.* This is evident from the numberless arterial ramifications that pervade the palatine, nasal, or pituitary membrane, and indeed almost entirely construct it (*y*); from the wedge-like confascicu-

respiration for a time; of turning away our faces; or of removing ourselves altogether from the locality of the noxious exhalation.

(*x*) See above, note (*p*).

(*y*) Such is the abundance and luxuriance of arteries in the pitui-

lation of these little arteries, and their termination in excretory glands (*z*): from the multitude of filaments and ducts that run over the membrane, and protrude by their orifices into the cavities of the nares (*a*): from the fungoid and cellular texture of

tary membrane, that one would be inclined to say it was composed of nothing else. See Ruysch's Tabulæ. Vieussens, who agrees with me in stating that this membrane abstracts a pituitary and mucous humor from the blood that is ascending to the cerebrum, speaking of the arteries of the membrane, has the following; "This membrane is supplied with much more numerous arterial ramifications than the other parts of the mouth; they terminate in plexuses not unlike those of the placenta" (*Neurogr. Univ.*, lib, i., cap. xvi.) The same inference again may be deduced from the common office of this organ, (since we may pass by induction from the general to the particular,) namely, that it carries away the pituitæ of all the organs of the head, and therefore purifies them, both in the whole and the parts, (but by two ways,) from the ichorous inundation.

(*z*) You will also find these glands figured in Ruysch's Tabulæ mentioned above, n. 342. "The excretory ducts [of the glandular granules]," says Winslow, "are very long near the septum narium, and their orifices very visible" (n. 340).

(*a*) It is evident from the description of these ducts and glands, that they absorb and carry off into the cavity of the nares, the pituitary lymph between the two membranes; that is to say, between the pituitary membrane and the periosteum, and also the lymph that is flowing down through the cellular tissue of the pituitary membrane; for the glands appear on the former part, but the orifices of the ducts on the latter especially. Vieussens speaks of these ducts; "We observe on this membrane," says he, "not only blood-vessels, but also great numbers of short ducts, which, in consideration of their office, I term vasa mucifera. These are principally seen on that portion of the membrane which is appended to the posterior part of the vomer, and of the two ossa palati" (*Neurogr. Univ.*, lib. i., cap. xvi.) And Winslow says, "By applying a blow-pipe to any of the orifices, the ducts may be inflated through nearly their whole extent" (n. 340). That innumerable foramina open in the cavities of the nares, is also declared by Vieussens; "The surface of this membrane," says he, "is perforated in many parts by numerous small foramina; if it be pricked with a needle, or squeezed between the fingers, mucus immediately exudes from it; and if it be removed and placed in water, it imbibes the water

the same membrane (*b*): from its continual excitation by the varying influent air, and by the nidorous [or ammoniacal] parts thereof, which either sooth or fret it: lastly, from the common trembling of all the parts, when the tongue and larynx are speaking. Thus the nasal organ is the common emunctory and purificatory of the blood which is mounting to the cerebrum; and of that which is turning aside to the organs of the senses,—of sight particularly, and also of hearing and taste. The salivary glands, indeed, as the parotids, the maxillaries, and several others, are also emunctories of the same blood, but subordinately to this common emunctory (*c*). *The nares also immediately derive from all these organs the ichorous streams that threaten inundation; as, for instance, from the eye.* This is plain from the lacrymal duct or sac (*d*): from the close vicinity of the nose to the eye: from its intimate connexion therewith by means

like a sponge" (*Neurogr. Univ.*, lib. i., cap. xvi.) But these foramina are not continuous with the before-mentioned ducts, but seem to come from the intermediate cellular tissue, and to provide a passage and outlet for all the lymph that is poured out there, or flows down thither.

(*b*) Respecting the fungoid structure, see Vieussens above, note (*a*). Respecting the cellular tissue, Winslow says, "If we make a small opening in it [the membrane] with the point of a scalpel, . . . and use the blow-pipe, we discover a very extensive cellular substance" (n. 340).

(*c*) That the salivary glands also secern the pituitæ of the blood, see Part I., the Chapters on the Tongue, the Palate and the Pharynx; also those on the Liver and the Pancreas; which organs likewise reduce the impure blood, and convert it into salivary juices. But that the pituitary membrane draws off the grossest fæces of the blood, is plain from the excitative causes whence the attractive [causes in this part are derived]; we mean, from the continual ingress, transit and egress of the air; from the impulse and irritant action of angular particles upon the organs of smell; and from the general trembling excited by sounds, &c. No excitation similar to this has place in the salivary glands, but they are stimulated to their actions by the motion of the tongue, particularly during eating; wherefore they are only subordinate emunctories. From the excitative causes we may conclude respecting the quantity, and in some measure also respecting the quality of the excretions from the arteries.

(*d*) Respecting this little sac, see Heister, n. 336; Winslow, n. 340.

of little bones, coats and muscles: and from the arterial ramifications which come off from the more considerable branches, and run to the eye (*e*). Likewise *from the ear*, through the Eustachian tubes (*f*). Also, *from the sinuses of the cranium*,—from the frontal, sphenoidal, and maxillary sinuses,—and perhaps, too, interiorly from the interstices, cells, openings, and clefts in the corresponding and other bones of the head (*g*). That the nares derive certain streams from the cavities of the six sinuses, is rendered probable by the continuation of the nasal membrane; by the communication of the air; and by the visible and discoverable perforation. And that an exudation is conveyed between the membranes, is testified by their loose connexion with each other, even in the very sinuses of the bones; by their expansion into vesicles when inflated (*h*); and by the absorbent and interfluent ducts, conveying the discharges outwards (*i*).

(*e*) It is worthy of remark, that the arterial branches supplying the eye, come principally from the branches that go to the pituitary membrane; thus they more particularly abstract the pituitæ from the blood, for the organ of sight. The same conclusion may be drawn from other phenomena, as from the fact, that the sight is rendered remarkably clear by the use of snuff and other stimulant powders.

(*f*) That certain determinate ducts carry off the serosities of the internal ear, and also the air itself, particularly from the cavity of the tympanum, will be seen in the Part on the Organs of the Senses.

(*g*) There are perpetual communications between the nares and the innermost parts of the bones; but no great number of little foramina have yet been discovered; for the pituitary membrane ramifies uninterruptedly upon the very leaves and cells of the bones. "The ethmoid bone," says Winslow, "is of a very fine and delicate structure, although compact and without any diploë; being almost entirely composed of divers thin, bony plates. It is connected to the frontal, sphenoidal, nasal, maxillary and lacrymal bones, and to the palate bone and the vomer. Its use is, to give great extension to the pituitary membrane, in a small compass" (*Exp. Anat.*, *Tr. des Os Secs*, n. 252—254). It would also seem, by its fissures and foliaceous interstices, to afford a passage for the humor that is oozing from the cellular compages of the adjoining bones.

(*h*) See Verheyen, *Corp. Hum. Anat.*, tract. iv., cap. xx., and particularly tab. xxviii., fig. 4, 5.

(*i*) See above, note (*a*).

348. *The nares draw off the pituitary lymphs from the medullary and cortical portions of the cerebrum, and from its meninges or membranes.* Of this we are fully assured and convinced by the continuation, connexion, and structure of all these parts; by the determination of motion, the excitation of cause, the manifest permeability, and by visible effects: the *continuation*, namely, and production of both the meninges, and of the olfactory fibres, from the pituitary membrane, through the foramina of the cribriform plate, over the whole surface and medulla of the cerebrum (*k*). The *connexion* and communication of the same membranes, with all the interior fibres and membranes, even to the cortical termini (*l*). The plexiform and porous

(*k*) The particular passage or running-forth and extension of modifications and subtle vibrations and undulations, is to be inferred from the continuity of coherent or solid parts, particularly of solid similar parts, and from the continuity of fluid parts; consequently, in the animal microscosm, from the continuity of the fibres and membranes, and in the macrocosm, from the continuity of the particles of the atmosphere. This property of modifications is truly amazing, for wherever impressed or originating, they pour forth along everything continuous and contiguous, and only when exhausted, either by gradual diminution of elasticity or increase of gravity, do they die away and cease to be perceptible. If then we are to judge from continuity, it appears, that the sensual fibre,—in the present case the olfactory fibre,—is continued without any interruption through the fibres of the mammillary processes, and into the meninges of the pia and dura mater; for the fibrillary fasciculi are covered over in their course, with both the meninges, as with little sheaths. See n. 345 (*p*). And if the meninges follow the very fibre all the way to its organic ends, that is, to the papillæ, and possibly there enswathe the first minute individual sensoriola with some kind of most fine membranous film, or connect them with the fibres, then the consequence will be, that when the little organ is touched, these extremes of the two membranes must also be affected by the contact, and modified, and the modifications continued inwards into the cerebrum. And if this be the case with the fibre and the two meninges, then the humor contiguous to them must necessarily become participant in the same vibration.

(*l*) If, as we have just said, we are to judge of the extension of the olfactory modification, from continuity and contiguity, then, taking anatomy as our guide, it appears, that the fibres of the olfactory nerves,

structure of the medullary substance (*m*), and the convoluted and open structure of the cortical substance (*n*), which is conti-

if they are not absolutely continuous with the fibres of the whole medulla cerebri, nevertheless communicate with them in a wonderful manner; for when those mammillæ or processes, (which are hollow in the seal,) are inflated, the whole medullary centre of the cerebrum expands, according to the experience of Willis; shewing that there is a communication between the olfactory fibres of the nose and the whole medullary fibre of the cerebrum. That this communication, however, is only general, and indeed, with the fasciculi, lamellæ or plexuses of those fibres, will be shewn in the Part on the Cerebrum; consequently that it is a communication with all the interstices of the fasciculi or plexuses through which a constant stream of gross and pituitary lymph is flowing. If then there be such a communication with the universal compages of the medullary substance, then of consequence there is a communication thereby with the cortical substance itself, which is the source of the fibres. The same conclusion may be deduced from the place where these processes have their roots or origins, namely, between the corpora striata and the thalami nervorum opticorum; which situation is the meeting-place and common forum of all the fibres that descend to the medulla oblongata. But with respect to the membranes, the dura mater communicates throughout with the pia mater entirely by the interchange of filaments and vessels; while the latter communicates more immediately with every portion of the cortical substance. Thus there is a double or triple communication between the olfactory fibres and the cortical substance; namely, by the fibre, and by the meninges: hence in the cortical substance itself, which occupies the place of a centre of all things, there is a meeting of the modifications. From these considerations it follows, that a similar action is communicated to the whole of the interfluent and contiguous pituitæ; for not only sensuous modification, but also those other more violent modifications which are properly termed tremors, penetrate thither.

(*m*) We shall shew in the Part on the Cerebrum, that its medullary substance is exceedingly porous, and being plexiform, therefore permeable in various directions from one extremity to the other; and that the larger passages or channels run continuously towards the roots of the mammillary processes.

(*n*) The convolutions of the cerebrum, formed by the joint disposition of the cortical glands, are not unknown to even tyros in anatomy. All these convolutions intercommunicate, and by a continuous spire of circumvolution are determined to the two extremities of the axis;

nually moistened by dripping arteries: likewise, the extensive cavity between the two meninges. The *determination of motion*, namely, from the whole of the centrum ovale, or medullary globe, towards the roots or origins of the mammillary processes, and from them, as well as from the whole convoluted circumference, to the cribriform plate; as it were from levers and peripheries, through determinate paths, to a centre of gravity and rest; which line of direction all the fluids of the cerebrum equally as of the body, are bound to follow (*o*). The *excitation of cause*,—from the air attracted alternately; from the contact and stimulus of odoriferous particles; from the tremulous vibration of the laryngeal sound: all which pervade every continuum, and excite the animations of the cerebrum to reciprocations synchronous with the respirations of the lungs; thus giving rise to a perpetual determination of the contiguous and enclosed humor, to its natural reservoirs and outlets, consequently towards the cribriform plate (*p*); in which there is a *manifest*

namely, to the fourth sinus, and to the cribriform plate. Hence, if a stream of humor pass along the course of the furrows, and the unending flux of the convolutions, it cannot but be carried to the cribriform plate, which is in one axis of those spires. Consequently, if any fluid be passing between the two meninges, then such fluid, occupying the natural channel of the fluxion and derivation, and following the gyres of the convolutions, must be determined to the crista galli or spina coronalis, as its ultimate port and asylum; for this spot is the first and last boundary both of the sinuses and processes of the dura mater, and of all the convolutions of the two hemispheres of the cerebrum. Granting, therefore, the alternate constriction and expansion of the cerebrum, consequently, the alternate opening out and contraction both of the convolutions on the surface, and the channels in the interior, then it follows, according to the natural laws of hydraulics, that there is a moving forward of the intercepted fluid or pituitæ towards this ultimate goal or station.

(*o*) According to the statements just made, the anatomical experience proper to which will be given in the Part on the Cerebrum.

(*p*) It will be seen presently, that the cribriform plate occupies, or is situated at, the extremity of the axis of the whole of the cerebrum, and that on the outside of the ethmoid bone it is continued to the axis of the body extending into the thorax: and we have shewn already

permeability between the fibrillary filaments, and between the two meninges which accompany them outwards to their organic terminations in the form of little distinct sheaths; and which, actuated by the alternate motion of the cerebrum, by a kind of pumping action, afford the lymphs an opportunity of passing alternately through their minute interstices (*q*). We

thoughout our Analyses that all fluid that passes through the pipes and continuous foramina in the animal body, tends by a natural determination towards the axis, and from the axis to its extremity. Consequently, should any humor be collected in any part, within either the pulpy medulla, or the granular circumference of the cerebrum, or between the meninges, such humor is necessarily forced, by the alternate animation of the cerebrum, to the extremity of its axis; the more especially, since various external causes operating to excite the cerebrum to the reciprocal movements of respiration, exist in the nasal cavities, where the extremities of the fibrillæ and of the meninges of the cerebrum are nakedly exposed to divers impulses.

(*q*) There cannot, I think, be any reasonable doubt with respect to the permeation of humor between the two membranes, the pia and dura mater, even in the very foramina of the cribriform plate, where the membranes, laid and applied one upon the other, issue out to the pituitary membrane; were there any concretion or growing together of the membranes, there could be no possible distinctness in the sense of smelling. Upon the cerebrum itself these two membranes are perfectly distinct from each other; consequently they are also distinct in those places where they appear to be more closely united. If there be a space intervening, of course all the humor that is contained between the membranes, must be carried thither along the stream of determinations, and consequently must tend to enter those interstices: and not alone between the membranes, continuously from the common cavity between the same, but also between the fibres under the pia mater itself; for every fibre, and every fasciculus of a fibre, is divisible from its fellow, and acts distinctly; were it otherwise, there could be no distinct vital operations. Granting, then, the alternate expansion and constriction of the cerebrum, we also grant the alternate elongation and contraction of the fibres and fasciculi, consequently the alternate opening and closing of the interstices,—the interstices, namely, between the fibres enclosed in the pia mater, and also between the membranes themselves in these little foramina; consequently, again, we grant a species of reciprocal pumping, such as cannot by possibility exist in collapsed

are also convinced of the same thing by *visible effects;* namely, by the sensible vermination and creeping of the catarrhal humor which comes from the cerebrum; by its derivation towards this part of the surface of the face; by its discharge into the antra or cavities of the nares; or in case these are closed up, into the nerves of some other region (*r*); by its more full and rapid

and dead, but only in living and breathing brains. Judging from the dead subject, Vieussens and others after him have erroneously formed a contrary opinion; and some call this transpiration in question; as Heister, who says, "Whether the nares let out the pituita or blood from the cerebrum, as the ancients and Slevogt will have it they do, or not, is still a matter of doubt." (*Comp. Anat.*, n. 286.) Merely for this reason, that when the head of the dead subject is held downwards, no pituitary humor, or spirit of wine gently thrown in, is observed to escape! But hitherto, so far as my knowledge extends, the attempt has never been made with fluid injections thrown in between the meninges, before a sufficient time has elapsed for the parts to become agglutinated; or before they have collapsed so firmly as to block up the passage, and begun to repel the fluid thrown in, by a folding or reaction caused by the force of the injection. Hence I fear the right conclusion has been too stoutly and obstinately resisted, although fully borne out by plain facts and phenomena. Tell me, I beseech you, what other place of discharge has been discovered. On the other hand, we know that it is undeniable that there is a continual afflux of lymph between the membranes, and under the pia mater, between the convolutions, and in the medullary substance itself; to say nothing of the lymph in the ventricles, from which the humor is carried off through other secret ways. In no part of the cerebrum or its meninges do we find venous orifices, such as absorb collections of pituita, but arterial structure prevails throughout, and gives off its excretions; nor is there any passage in the direction of the sutures, nor through the transverse septum into the chamber of the cerebellum, and this way into the spinal marrow; still less through the dura mater, by oblique channels to the bony cranium, from which all pituita of the kind is carefully kept away. But this discussion respecting the olfactory nerves is merely preliminary; we shall canvass the subject point by point, and more fully, in the Part on the Cerebrum.

(*r*) Nothing is more common in northern climates than the perception of the creeping of catarrhal humor in the cerebrum, and its sensibly-felt derivation into the nares. I should fall short of the truth were

escape upon the application of sternutatory substances; in fact, by the very phenomena of sneezing (*s*): also, by the existence of ichorous collections between the membranes, in the sponge-like medullary substance, and in the ventricles, as observed in *post mortem* examinations of the brains of those who have died of apoplexy, epilepsy, paralysis, or hydrocephalus; and whose restoration to health would be a matter of impossibility, unless this outlet for discharge could be properly opened.

349. V. *By an extrinsically impulsive force, the nares excite the cerebrum to its proper reciprocal animations, synchronous with the respirations of the lungs.* Of this we are likewise assured by the causes of the former effect (*t*), which are, indeed, common to this its fellow; that is to say, by the continuation, connexion, and communication of the fibres of this organ, with all the parts, individually and collectively, in both the medullary and cortical portions of the cerebrum: by the perpetual irritation, so long as we breathe the breath of life, arising from the air charged with odors, and by its varying afflatus and contact, affecting, titillating, twitching, and pricking the organic tissue,

I to say that I have myself experienced it more than a hundred times.

(*s*) From the phenomena of sneezing, which is the greatest expansion, and the sudden constriction, of the cerebrum and the lungs, we may see what are the lesser effects and exciting causes of respiration; for the cause is the same in both cases, and the difference is only a difference in degree,—the difference between great and small. The greatest degree of titillation and stimulation excites a total elevation, as it were, a convulsion of the cerebrum; a lesser degree excites a similar but more slight effect. It is a plain matter of experience, that the dura mater, and consequently the hemispheres of the cerebrum, are violently contracted and expanded in sneezing; for in wounds of the head, where portions of the calvarium have been lost, the contraction of this membrane is sensible under the finger, and even visibly perceptible. Thus the purification of the cerebrum from humor, and the discharge thereof through the manifold natural outlets of the cribriform plate, as well as from the other cavities and sinuses, must certainly take place; being a necessary consequence of such contractile and expansile motion.

(*t*) Respecting which, see above, n. 348.

in general and in particular, and occasionally rousing both the cerebrum and the lungs to almost convulsive expansions and constrictions (*u*). But there are differences in this respect in different living creatures: the human race has the power of respiring through the mouth as well as through the nose; in order that the cerebrum may be excited to its alternate reciprocations of elevation, solely by causes within its own power,—by internal causes,—and not at the same time, except so far as it wills, by external causes (*x*): so that nothing may sever or interrupt the analyses of its rational mind, and their tacit and quiet guidance (*y*). In confirmation of this fact we may also add that

(*u*) I mean, to sneezing, which is the greatest degree of expansion and constriction of the cerebrum. See above, note (*s*).

(*x*) In order to the knowledge and exploration of causes from effects, it is of the first importance to know the influx and coöperation of the causes of any given effect; but this is a subject of vast extension. We must here confine ourselves to stating, that causes are divisible into innermost, middle, and outermost. In order that the cause may produce the effect, all these must necessarily coöperate. The innermost are the proper causes of the efficient,—they are the causes belonging to the very principle; but the outermost, although evoked by proper causes, nevertheless should not be termed proper excepting with respect to their descent and evocation. The innermost causes act most individually, that is to say, separately or singly upon every individual part; but the outermost causes act upon all the parts generally: thus the outermost represent the common bond of singulars. To give an example: the cerebrum, from the causes belonging to its principle, whether that principle be nature or the will, excites each substance of the cortex and each fibre to a species of animation; yet the cerebrum requires also to be excited to the same reciprocations by some other and general principle; as in the present case, by the air flowing into the nasal cavities, which operates in a general manner, not only upon the whole of the fibres, but also upon the whole of the meninges, and by this means upon the cortical cerebrum, where the principles with their powers reside. The cerebrum acts, by the fibres, upon all the veriest particulars of the body; the lungs also act upon the same, but only upon the general compages of the fibres, thus upon the organs formed by the fibres. So in all other cases.

(*y*) Every one knows from his own experience, that while his mind

350. VI. *The nasal cavity and prominence, like a cynosure, terminate and complete a common axis.* This proposition is proved by the situation of the ethmoid bone, and its connexion with the coronal, the sphenoid, the two maxillary, and the lacrymal bones, and with the palate bone and the vomer, to which it serves as a boundary, common bond, fixed point, and wedge (*z*); also by the articulation of the other bones by means of sutures, particularly by means of the frontal suture in young subjects (*a*). That the cribriform plate of the ethmoid bone is

is revolving its ideas or reasons, and thinking intently, he retains or suspends the respirations of the lungs, consequently also the breathing of the cerebrum, for a considerable interval; and takes every means to prevent any deep inhalation of the air, from disturbing its rational analyses or analytic equations. For when the mind is in this state, it demands the most profound silence and the most perfect quiet. This suspension of breathing takes place, in order that everything of the grosser blood may be driven away, or kept at some distance, from the innermost organs; for the blood penetrates deeply when the cerebrum breathes or animates deeply. Hence man enjoys the power of transmitting the pulmonic breath through the aperture of the lips, and through the mouth; and thus the external cause is prevented from exciting the internal, (as it does in brutes,) and the internal is constantly enabled to call forth or evoke the external.

(*z*) This is sufficiently shewn by the facts of osteology. The bones of the cranium are mutual props and supports to each other; and each bone has its middle terminus, which it respects as a centre; for both in the part and in the compound there is a perpetual respect of centres, axes and circumferences, which results in the unbroken nexus and correspondence of all things. With respect to the cribriform plate of the ethmoid bone, Winslow says, "The middle part of this portion of the ethmoid bone is a small horizontal lamina, perforated by several foramina, and termed, cribriform plate; posteriorly it has a little notch for its articulation with the sphenoid bone. This plate may be looked upon as the body and support of the whole bone" *(Exp. Anat., Tr. des Os Secs,* n. 245). In the skeleton, the prominence of this part is particularly conspicuous, and we see clearly that it proceeds, as the extremity of an axis, from the point of junction of the other bones.

(*a*) The sutures respect each other mutually, in the same manner as the bones. In embryos and infants we generally find a suture running from the sagittal suture towards the ethmoid bone, and going to

moreover placed at the extremity of the axis of the cerebrum itself and its membranes, is shewn by the longitudinal sinus, and the falciform process of the dura mater; by the serpentine gyres of the hemispheres; likewise, by the median fissure, running from the fourth ventricle, through the aqueduct of Sylvius, the third ventricle, and the septum lucidum, to the fissure of the anterior convexities of the cerebrum (*b*); all of which have their starting-place and goal at the crest and plate of this bone: also, by the communication of the mammillary processes with the whole of the medullary nucleus and of the cortical circumference (*c*). *The nares also institute and begin the common axis which runs from the head into the thorax, as well as that which runs into the abdomen;* to wit, through the larynx and the trachea to the lungs, and through the pharynx and the œsophagus to the stomach; which ways the pituitary membrane continuousl follows, lays down and smooths, from the superior boundary o the axis, far beyond their respective thresholds (*d*). From such

the dorsum of the nose; and which sometimes unites with another that comes round from the coronal suture to the orbits. These very sutures or articulations, like the bones themselves, are indications of mutual relations and directions.

(*b*) All these particulars will be clearly explained in the Part on the Cerebrum. See below, note (*d*).

(*c*) These points were treated of in the preceding paragraph.

(*d*) It may be proper to indicate, at this preliminary stage of our investigations, that two very remarkable axes are observed in the cerebrum: one runs from the crista galli, along the longitudinal sinus and the falciform process of the dura mater, that is to say, along the great fissure of the hemispheres, all the way to the fourth sinus or torcular Herophili; the other runs in the middle or central portion of the cerebrum, from the fissure of the anterior convexities,—thus like the former, from the region of the crista galli or cribriform plate,—through the septum lucidum, the third ventricle, and ultimately through the fourth, all the way to the spinal marrow, and is a hollow axis, but intercepted by divers partitions. The very surface of the cerebrum, convoluted as it is, and wound into serpentine spires, and the whole of its interior or medullary portion, respect these axes as continual goals, to which with one accord they tend. The cerebellum refers itself to the spinal marrow, as a kind of axis continued from itself. But in the body there

continuity, connexion, and communication in the extreme boundaries,—in the last boundary of the head, and the first boundary of the body,—there exists a common correspondence of all things, and the same correspondence is excited alternately by the contact of the air or breath as it passes by.

351. VII. *Thus, from the ultimate boundary of this axis, the nares transcribe the cerebrum into the face, and give it the power of picturing its affections upon the surface or countenance thereof.* For from this boundary, as a kind of pole or centre, the cerebrum evolves itself into new circumferences, and in order to be continuous with them, it produces its axis into a beaked protuberance,—in fact, into a nose,—and perforates this nose with cavities, divides these cavities from each other by a septum, furnishes them with alæ, and connects them, by means of coats, ligaments, and muscles, with the lips, cheeks, eyebrows, and forehead, suitably to every idea of the animal mind's representation (*e*). Hence correspondence, symmetry, beauty; and a na-

seems to be three general axes proceeding from the ethmoid bone; one running through the pharynx and the œsophagus into the stomach, and which serves as an axis in the whole of the cavity of the abdomen, as we shewed in the Chapter on the Peritonæum: the second passing through the larynx and the trachea into the lungs, which are the general beginning or principle of all the motions of the body: the third going towards the spinal marrow, which, as we before observed, is the axis of the cerebellum. That there is also some passage thither from the cavities of the nares, may be gathered from an observation of Winslow. "The particular situation of these cavities," says he, "deserves our attention: the bottom of them runs directly from before backward, so that a straight and pretty large stilet may very easily be passed direct from the tip of the nose, as far as under the great apophysis of the occipital bone" (n. 340).

(*e*) The proper muscles of the nose are two dilators, the pyramidalis and the myrtiformis; also one constrictor, figured by some anatomists, and named by Brown, corrugator nasi; to which we may add, the semilunar or falciform muscle of Eustachius, represented in his *Tabul. Anat.*, tab. xviii., fig. 3. In the plates of Eustachius and other authors, as Cowper, Bidloo, Brown and Santorinus, we see that nearly all the labial and the frontal and palpebral muscles communicate by a wonderful influx with the nasal muscles. See Eustachius, *Ibid.*, tab.

tural and instinctive divination from the form of this prominence respecting the cerebrum, or respecting its animal mind, which in the face, constitutes expression (*f*).

352. The UVULA is a conical and pointed corpuscule, hanging like a plummet or inverted balance from the junction of the arches and columns of the velum palati; like an elongated drop or tear from the roof of the nasal chamber; provided with great numbers of muscles, termed musculi staphilini, which arise from the pharynx, the larynx, the root of the tongue, the palate, and the Eustachian tube; furnished with numerous vessels; excavated by little mucous crypts; surrounded by the membranes of the palate and nares; reaching forwards to the root of the tongue; flexible, capable of elevation, relaxation,

xi. and xviii. Thus confirming our proposition, that the whole face, by means of the muscles, refers itself to the nose, as a kind of prominent axis. But it was pointed out above, in our Chapter on the Mouth and Lips, that the labial orifice occupies the place of a kind of centre, the circumference of which centre is moveable, and that by means thereof the face acquires the capacity and power of representing infinite species of motions or expressions. On the other hand, the uppermost part or root of the nose is an immoveable centre, from which a radiation takes place to all points of the face as circumferences; which is the reason why there is so close an intercourse between these two centres; for nearly all the nasal muscles operate upon the labial muscles, and *vice versâ*. Every one may experience this in his own person; for the alæ nasi cannot be expanded without a simultaneous opening of the lips, nor can the two be compressed except together.

(*f*) Thus we observe various classes of noses,—some aquiline, long and hooked, some pinched; others again, turned up, crooked, bulbous, retracted, grooved or double; others again, small, sometimes so small as to consist of little more than alæ; and if these forms be congenital, not attributable to the mother's influence during pregnancy, we shall rarely be deceived in judging from them. For if the state of the animal mind,—whether it be anger, or melancholy, or sorrow of any kind, or pride, or shame, or disgust, or contempt, or gladness, benevolence, kindness, or the like,—be cognizable from alterations in the countenance, then of course a very similar form in general must be communicated to the infant by the nature hereditarily propagated from its parents. It does not, however, seem that this rule ought to be extended to anything beyond the signs of the disposition or animal mind.

contraction and extension, and determinable to all the modes of the tongue, the pharynx, the larynx, and the palate, when these parts are in action; particularly and proximately to the modes of the velum palati. Its uses are, *Firstly*, to give the velum palati the full power of accommodating itself to the actions of the tongue in eating, and of the pharynx in swallowing (*g*): this end being answered by the glosso-staphilini and pharyngo-staphilini muscles, assisted by the palato-staphilinus and the azygos Morgagnii (*h*); also by its membranes, continuous with the integuments of the mouth and fauces. *Secondly*, likewise to assist

(*g*) The uvula appears to do no more than bestow upon the velum palati the opportunity and power of accommodating itself to the respective modes of the tongue in eating and speaking. It is only a pendulous corpuscule, capable of elevating itself, contracting and expanding; but like a plummet or balance it lends and communicates to the velum palati, a wonderful readiness and faculty of application. It is, in fact, a perfectly moveable apex, to which the divers actions of the velum can in an instant be concentrated, and thus the velum be nimbly inflected and folded to suit the minutest variations of the tongue and the pharynx; which would be very difficult of accomplishment without some weight or poise of the kind: for the circumferences, scattered all round, obtain their ability of moving, from the moveable axis; inasmuch as it receives all the vibrations and inflections, as well as accommodates itself thereto. The velum palati closes the passage, either to the larynx, or to the nares, or to the Eustachian tube, or to the pharynx; but not so the uvula, which turns like a balance according to all the little motions of its scales. Respecting the velum palati, and the palatine arches and columns, and respecting the manner in which the uvula depends therefrom, see Winslow, n. 341. But no author, I think, has more diligently and successfully than Boerhaave, investigated the foldings of the velum palati, and the various determinations of it and the uvula, both when the tongue is eating and speaking. See his *Inst. Med.*, n. 70, 71. For Boerhaave has taken the opportunity of examining the parts under these circumstances with a lighted candle; and has shewn how readily this little cone accommodates itself to the various actions of the velum. Indeed to him I principally owe my knowledge of the uses of this corpuscule.

(*h*) According to myologists, the glosso-staphilinus, arising from the root of the tongue, ascends towards the palate and velum palati. The pharyngo-staphilinus, arising from both sides of the pha-

the velum or claustrum palati, when the larynx is articulating, and the tongue regulating, sound: this end being answered by the glosso-staphilini, the thyro-staphilini, the salpingo-staphilini, and the pterygo-staphilini, assisted by the palato-staphilinus (*i*): and hereby is conferred the power of respiring, modulating, and speaking, either through the mouth, or through the nares, or through both; which seems to be the reason why the uvula is not found in brutes. *Thirdly*, the uvula provides that the pituitary and mucous humor of the nares, following the continuous parietes, and proceeding and determined by this ready road and extended path (*k*), may be derived, not into the rima glottidis, but

rynx, proceeds in like manner, through the velum palati, towards the uvula. The palato-staphilinus, coming from the junction of the palate bones, is inserted into the upper part of the uvula; so likewise is the azygos Morgagnii. See Heister's description of these muscles, n. 339. It appears then that the uvula does nothing of itself,—nothing except by means of the velum palati.

(*i*) These muscles respect the coöperation of the velum palati, and thereby of the uvula, with the tongue and the larynx; as the former respect the coöperation of the same parts with the tongue and the pharynx. The thyro-staphilini, according to Heister (n. 339), arise from the lateral part of the thyroid cartilage, widen as they ascend towards the uvula, and are inserted, in the manner of an arch, into the side of the velum palati. The salpingo-staphilini arise from the posterior part of the Eustachian tube; the pterygo-staphilini, from its anterior part. The way in which the Eustachian tube contributes to sound and speech, will be pointed out in the Part on the Organs of the Senses, in our Chapter on the Ear.

(*k*) All humor, even the most limpid, still more that which is sluggish and mucous, constantly follows the parietes, and descends along the plane surfaces; it never escapes from the middle of the aperture of an osculum, unless its quantity be great and superabundant. Since then the uvula hangs forward from the border of the orifice that opens from the nares into the cavity of the palate, therefore the mucus descending from the nares cannot possibly follow any other than this ready and continuous path, that is to say, along the uvula; consequently it must pass to the very root of the tongue, with which the uvula is in contact by its apex. Thus the uvula is the guide of the mucous drippings or discharges from the narine cavities into the palate, and the mover forward of the same towards the pharynx.

to the root or dorsum of the tongue, and thence into the pharynx; and thus that it may not be commixed with the saliva of the mouth, and blunt the delicate and agile fibres of the tongue, and the sensoria of taste (*l*). These causes are confirmed by the actual effects witnessed in the mouth, on holding a lighted candle to it when the tongue is eating or speaking (*m*): by the change of state in both these operations when the uvula is inflamed, stiffened, tumefied, bent, detached from its muscles and fræna, excised, ulcerated, or eroded: and lastly, by the situation and connexion of the uvula, and by its powers of inflexion, contraction, extension, and application.

(*l*) The direction of the mucus that comes down from the nares, is alone sufficient to prove that it is different in nature from the saliva of the mouth; for the interposition of the uvula, and its determination towards the pharynx, make it evident, that the only proper ways of discharge for this mucus, are either through the nasal doors or apertures, or else immediately into the pharynx, where it can be commixed with the thick humor that is expressed from the palatine glands; possibly also where it may likewise sheathe the crumbs and little pieces of comminuted food, and convey them through the œsophagus into the stomach. For the salivary humors increase in density from the lips all the way to the pharynx; and at last they are succeeded by mucus, which is more muddy and thick than the other humors, and completes the work. It is very clear, that without some guiding cone like the uvula, the mucus of the nares would glide down promiscuously either to the tongue, and so to the apex thereof, or else into the larynx; particularly since the tongue is frequently speaking in the very middle of the act of eating; and thus pervert the established order of nature in the case of both these operations.

(*m*) That is to say, by Boerhaave, to whose observations (*Inst. Med.*, n. 70, 71) I again direct the reader's attention.

CHAPTER II.

THE LARYNX AND THE EPIGLOTTIS.

353. Heister. "The larynx is the thick upper part or head of the trachea. It contains an aperture leading to the lungs, termed the glottis, which is nearly elliptical, and furnished with cartilages and muscles, by means of which it is dilated or straightened, so as to produce the wonderful variations of the voice in speaking and singing. The larynx is principally composed of cartilages, which are five in number. The first is the thyroid or scutiform cartilage: it is a kind of quadrangle, and is placed in the anterior part of the neck, where it forms the prominence commonly called the pomum Adami. The thyroid is the largest of the five cartilages. The second is the cricoid or annular cartilage: this may be considered as the base of the rest, occupying the lowest situation: the trachea is adherent to it inferiorly. The third and fourth are the two arytænoid cartilages; these form a kind of basin, of a singular figure: they are connected by peculiar articulations on each side, to the posterior and superior parts of the cricoid cartilage, to enable the glottis the more readily to be constricted and dilated. The fifth is the epiglottis; this is often of the shape of a leaf of ivy, and is joined to the superior and anterior part of the thyroid cartilage, over which it stands erect immediately behind the root of the tongue: and it is connected thereto by its middle ligament, but by its two lateral ligaments to the cornua of the os hyoides, and by its two posterior ligaments to the arytænoid cartilages. The epiglottis in the act of deglutition covers the glottis in the manner of a moveable bridge, and prevents anything from falling into it. The membrane which invests the larynx is very sensitive, and perforated with a great number of oscula or openings, which discharge a lubricating fluid. There are also glands termed arytænoid and epiglottidean, situated upon both surfaces of the larynx, and which secrete a mucous fluid that

serves for lubricating the whole of the trachea. The ventricles or sinuses of the larynx, are certain cavities, sometimes large and sometimes small, extending internally over the glottis, and assisting in the production of the voice. *(Comp. Anat.,* n. 259.)

354. "Of the muscles of the larynx seven pair are commonly enumerated; these have their names from their origins and insertions, and the principal use of all of them, is, to produce the variation of the glottis and the modulation of the voice. Of these seven pair two are common, and have their origin on the outside of the larynx: the other five are proper, and have both their origin and termination in the larynx. The common muscles are the sterno-thyroid and the hyo-thyroid. The sterno-thyroid draws the larynx downwards, and at the same time dilates the glottis. The hyo-thyroid elevates the larynx, and closes the glottis. The five proper muscles are, 1. The crico-thyroid, which appears either to dilate or constringe the larynx. 2. The crico-arytænoideus posticus, and 3. The crico-arytænoideus lateralis, which dilate the glottis. 4. The thyro-arytænoideus, which, together with the following muscle, constringes it. 5. The ary-arytænoideus arises frequently from one arytænoid cartilage, and is inserted into the other: these muscles on each side mutually intersect each other, and straighten the glottis: often there is only a single muscle; and often it is differently circumstanced from what is here described. Anatomists for a long time allowed the muscles of the epiglottis only to brutes, although Jacobus Sylvius has pointed out two elevators, and as many depressors, in the human subject; but of late they have been restored again to the human frame, and first, so far as my recollection serves, by J. G. Paul, who asserts that he has himself seen them. The elevators of the epiglottis are two in number, and of considerable length, reaching from the base of the os-hyoides to the posterior part of the root of the epiglottis; these he terms hyo-epiglottei. The depressors are likewise two, and smaller than the preceding; they extend from the apices of the arytænoid cartilages, obliquely forwards to the sides of the epiglottis; these muscles might be named, ary-epiglottei. *(Ibid.,* n. 324.) Littre, in the *Hist. de l' Acad. Roy. des Sciences,* an. 1718, assigns three muscles to the epiglottis, two depressors, and one elevator; but he does not describe them. Santorinus, however, describes not only one elevator, (of which I also lately observed some slight trace,) but four depressors, namely, two ary-epiglottidei and two thyro-epiglottidei majores; and besides these he mentions two thyro-epiglottidei minores, which serve, as he thinks, for bending down the middle part of the epiglottis: but these, by his own account, are so thin, particularly the last named pair, that they are scarcely perceptible, excepting in the

most robust subjects. For this reason, perhaps, I have never been able to observe anything answering to them, but certain delicate membranes." *(Ibid.*, n. 324, not. *l.)*

355. Winslow. "The larynx forms the protuberance that we feel at the upper and anterior part of the neck, and which is commonly called pomum Adami. Anatomists term it the head of the trachea. It is larger and more prominent in men than in women. It is principally made up of five cartilages: the thyroid, which is the anterior and largest; the cricoid, which is the inferior, and the common basis of the rest; the two arytænoid, which are the posterior and smallest; and the epiglottis, which is above all the others. These cartilages are connected together by particular ligaments, and they have likewise muscles, glands, membranes, &c., belonging to them. The thyroid cartilage is large and broad, and folded in such a manner as to have a longitudinal convexity on the foreside, and two lateral portions which may be termed wings or alæ. The upper part of its anterior middle portion is formed into an angular notch: the upper border of each ala makes an arch, so that the borders together with the middle notch resemble the top of an ace of hearts. The lower border of each ala is more even, and the posterior borders of both are very smooth, and lengthened out above and below by apophyses, of which the superior are longer than the inferior; these four apophyses I term the cornua of the thyroid cartilage. Their extremities are rounded, like small heads: those of the two inferior apophyses have a small shining surface on the inside, resembling an articular eminence. At the external surface of each ala, near the border, there is a prominent and slightly oblique line, which runs from behind forwards. The upper extremity of this line is near the superior cornu or apophysis, and both it and the lower extremity end in a small tuberosity; the lowest being often the most considerable. These tuberosities serve for the insertion of muscles and ligaments. The inside of the alæ, and the convex side of the anterior portion, are very uniform. This cartilage ossifies gradually in old age. The cricoid cartilage resembles a kind of thick irregular ring, very broad on one side and narrow on the other; or it may be compared to a small portion of a thick tube, cut horizontally at one end, and very obliquely at the other. In the erect position of the body, the base is almost horizontal, and to this the trachea is connected; so that the cricoid cartilage may be looked upon as the upper extremity of the trachea. The posterior part of the cricoid cartilage is larger than the other parts; and its posterior or convex surface is divided by a longitudinal eminence or prominent line, into two distinct surfaces, for the attachment of muscles. The top is gently sloped above, this pro-

minent line, and terminates on each side by a kind of obtuse angle, formed between it and the oblique edge of each lateral portion of this cartilage. At the upper part of each of these angles there is a very smooth and slightly convex articular surface. The whole of the posterior surface is divided into two lateral portions by two prominent lines, each of which runs down almost straight from the articular surface at the top, a little below the middle of this side, where it terminates in another articular line, somewhat concave. Near these four articular surfaces there are small tubercles. The two superior surfaces are for the articulation of the arytænoid cartilages; and the two inferior, for the articulation of the inferior cornua or appendices of the thyroid cartilage. The arytænoid cartilages are two small equal symmetrical bodies, which joined together resemble the spout of a ewer; they are situated on the top of the cricoid cartilage. Their bases are broad and thick, and have each a small concave articular surface, by which they are joined to the cricoid. Their cornua are bent backwards and a little toward each other. In some subjects they are very moveable, appearing like true appendices, and easily separable from the rest, as I demonstrated in my private courses about eight years ago. By their inner edges they form a kind of fissure; and their outer oblique edges terminate inferiorly by a thick prominent angle. The epiglottis is an elastic cartilage, nearly of the figure of a purslain leaf, narrow and thick below, thin and slightly rounded above, a little convex anteriorly, and answerably concave posteriorly. It is situated above the anterior or convex portion of the thyroid cartilage. Its lower extremity is attached by a short, pretty broad, and very strong ligament, to the middle notch in the superior border of that cartilage. It is pierced by a great number of openings, which are hidden by the membrane that covers its two surfaces. The ligaments of the larynx:—the thyroid cartilage is connected to the cricoid by several short strong ligaments,—round the articulations of the two inferior cornua with the lateral articular surfaces of the cricoid cartilage. The apices of the superior cornua are fixed to the posterior extremities of the great cornua of the os-hyoides, by slender round ligaments, about a quarter of an inch in length. In the middle of each of these ligaments, we often meet with a cartilaginous granule of an oval figure, and much thicker than the ligaments. The thyroid is likewise connected to the os-hyoides by a short, broad, strong ligament, one end of which is inserted in the superior notch of the cartilage, and the other in the lower edge of the base of the bone. There are also in the middle of the concave surface two particular ligaments, which belong to the arytænoid cartilages. The cricoid cartilage is connected to the lower part of the thyroid by a strong ligament, and round about

its lateral articulations, by the ligaments already mentioned, to the inferior cornua of that cartilage. Its base is attached to the first cartilaginous ring of the trachea, by a ligament exactly like those by which the other rings of the trachea are connected together. The membranous or posterior part of the trachea is likewise connected to the posterior part of the base of the cricoid cartilage. The glottis :—the arytænoid cartilages are connected to the cricoid by ligaments, which surround their articulations with the top of that cartilage. Anteriorly, the base of each arytænoid is fixed to one end of a ligamentary cord, which by its other end is inserted about the middle of the concavity or posterior surface of the anterior portion of the thyroid. At their insertion in the thyroid, these two ligaments touch each other, but a small space is left between them where they are attached to the two arytænoid cartilages; and they likewise appear to have a small adhesion to the top of the cricoid: this is what is called the glottis. The sinuses of the larynx :—under these two ligamentary cords there are two others, which run likewise from behind forwards. The interval between the superior and inferior cords on each side forms a transverse fissure, which is the opening of a small membranous bag, the fundus of which is directed outwards, that is, towards the alæ of the thyroid cartilage: these two sacculi are the ventricles mentioned by the ancients, and restored by Morgagni, who has given an excellent description of them. They are chiefly formed by a continuation of the internal membrane of the larynx; and the internal surface of their fundus appears sometimes to be glandular. The arytænoid glands :—on the anterior surface of the arytænoid cartilages there is a small depression between the basis and the upper convex part: this depression is filled by a glandular body, which not only covers the anterior surface of each arytænoid, but is likewise extended forward from the basis, over the posterior extremity of the neighboring ligamentary cord. These glands are larger and more conspicuous in some subjects than in others, and are covered by the membrane that lines the adjacent parts. They were discovered by Morgagni. I have already described the ligaments which connect the epiglottis to the notch of the thyroid cartilage, and to the basis of the os-hyoides. These two ligaments, meeting a third which ties the lower border of the base of the os-hyoides to the notch of the thyroid cartilage, form a triangular space, filled with a cellular or fatty substance, and with small glands. The epiglottis has likewise two lateral ligaments, by which it is connected to the arytænoid cartilages all the way to their points or cornua. It has also a membranous ligament, which running along the middle of its anterior or convex side, ties it to the root or base of the tongue. This ligament is only a duplicature of the mem-

brane that covers the epiglottis, continued to the neighboring parts. Lastly, there are two small lateral membranous ligaments belonging to it, fixed near the little glandular bodies, termed amygdalæ. The epiglottis is not only perforated by the regular holes already mentioned, but has likewise a great number of small irregular fissures and breaks of various kinds, which are so many different lacunæ, situated between its two membranes, and filled with little glands, the excretory orifices of which open principally upon the posterior surface of this cartilage," (*Exp. Anat., Tr. de la Tête*, n. 421—440.)

356. MORGAGNI. "Nothing has been more common in my dissections of the larynx, than to find the thyroid and cricoid cartilages of old subjects, either osseous, or in the process of becoming so, and a number of cells inside their substance,—in the thyroid, at the sides particularly, but in the cricoid, at the posterior part. I have often seen these cells filled with a medullary substance. (*Advers. Anat.* i., n. 23.) The glottis, which is the principal organ of the voice, is an oblong fissure formed by a number of little parts projecting on both sides into the cavity of the larynx; and which parts posteriorly ascend obliquely, but anteriorly are horizontal; wherefore the fissure also is similarly circumstanced;—it ascends obliquely in its posterior part, and is horizontal in its anterior part. The oblique portion of the fissure is formed by the two arytænoid cartilages, and also by the two long crura of the arytænoid glands; consequently this part of the glottis is double. The horizontal portion is also double. For on both sides it is formed of two white ligaments, or fasciculi of fibres, whereby the arytænoid and thyroid cartilages are connected to each other. . . . These two ligaments leave between them on each side a nearly elliptical fissure, which is sometimes long enough to admit the end of the thumb, sometimes only to admit the tip of one of the fingers, the difference being caused by the relative size of the larynx. These fissures are the orifices of two cavities . . . which are bounded inferiorly by the lower portion of the thyro-arytænoid muscles; posteriorly, to some depth, are covered in by the middle and superior fibres of the same muscles; and have the short crura of the arytænoid glands placed in part superiorly: for where they approach the base of the epiglottis the cavities become deeper, in consequence of the addition of appendages [ventriculorum appendices] of greater or smaller size; as may be easily observed by introducing a stilet. The interior parietes of the cavities are covered on all sides with the same membrane as the interior of the larynx; and hence they are perforated by a number of little foramina, particularly in the part where they are overhung by the crura of the arytænoid glands. Minute drops of a lubricating, viscid humor, ooze from these foramina. . . . The

ventricles of the larynx are closed in acute and expanded in grave tones. They are placed immediately within the circumference of the thyro-arytænoid muscles, and therefore also within that of the thyroid cartilage." (*Ibid.*, n. 16.) See also *Ibid.*, tab. i., ii., and *Advers. Anat.* v., Anim. 46, &c., &c.

357. Respecting the larynx, its cartilages, muscles, ligaments, and glands, see Eustachius, *Tabul. Anat.*, tab. v., fig. 1, 2, 3, 4; tab. xviii., fig. 2, 5, 6, 7, 8, 11, 15—26; with the commentary of Lancisi, and Winslow's notes in his *Exp. Anat.*, tom. v. Verheyen, *Corp. Hum. Anat.*, tract. iii., cap. xi., tab. xxii., fig. 1—12. Casserius, *De Vocis Auditusque Organis Historia*, and his *Tabul. Anat.* Boerhaave, *Inst. Med.*, n. 194; on the action of the larynx. Cowper, *Myotomia Reformata.* Santorinus, *Observationes Anatomicæ*, cap. vi., and tab. iii., fig. 1, 2, 3. Winslow, *Exp. Anat.*, *Tr. de la Teste*, n. 441—467; on the muscles of the larynx, &c.

ANALYSIS.

358. THE LARYNX and the EAR are two associate organs, and mutually stand to each other in the relation of married partners: something almost similar to connubial rites takes place between them; for the one conforms itself, exactly and absolutely, to the modes, measures, and actions of the other; when the one is active the other is passive, or what amounts to the same thing, when the larynx is sounding and speaking, the ear is imbibing and hearing the sounds and the speech (a). They live, however, in separate bed-chambers: the larynx resides immediately under the antrum palati, but having authority, it is also placed at the very top of the lungs, upon the air-pipe or trachea; while the ear lies concealed in a certain cave and labyrinth scooped out in the petrous portions of the temporal bones, under the foot of the cerebrum. Nevertheless, they assiduously communicate and consociate with each other, by sonorous and expressive motions; and this by two modes and by two ways: *Firstly*, by way of the membranes, cartilages, and bones, through the intervention of the Eustachian tube, along which all mur-

(a) Nature, in her greatest and least parts, has constantly associated together active and passive, the one to be the companion of the other; the agent or active, without the patient or corresponding passive, is a principle without a limit, by which alone no effect is produced; the passive must be present, as a mediate, determinant and coefficient cause of the effect. Thus the ear, which is a passive organ, not only receives the sounds and words of the agent or active organ, the larynx, but also determines them distinctly towards the cerebrum or general sensorium: hence an effect is produced, as it were an offspring, which offspring is an idea.

murs, words, sonorous tremblings and modifications, by an anticipatory passage, creep up directly into the ear (*b*). *Secondly,* by way of the winged air emitted from the orifices of the lips and nares, which conveys the sounds, modulated and told into

(*b*) Just behind the tonsils, in the palate, not far from the larynx, a certain tube, partly osseous and cartilaginous, and partly membranous, opens into the mouth: this tube was known to the ancients, but is best described by Valsalva. It comes hither directly from the cavity of the tympanum, and is so far pervious, that some persons by practice have learnt to transmit tobacco-smoke through it into the ear: it opens into the latter near the membrana tympani. This tube, besides deriving the recrementitious excretions of the ear, also forms a kind of bridge between the larynx and the ear; along which bridge, all sonorous vibrations, continued from the larynx to the membrane of the palate, and through the cellular portions of the temporal bones, are conveyed to the ear by an unerring determination; for sonorous tremblings always keep close along the path formed by filaments, membranes, and other hard bodies, all the way to the end; as we find clearly proved by cords held between the teeth, and connected by the other extremity to the sounding-board of a musical instrument. This is the reason why the deaf, —those in whom the external meatus of the ear is obstructed, or the membrana tympani destroyed,—open their mouths to take in sounds. Through this uninterrupted tube the sonorous tremor ascends to the ear,—the tremor that is not propagated through the air, but through the continuous membranes; and in order that the tube may afford a determinate passage, it is hollow, and constructed of elastic membranes, cartilages, and bones, put together in a wonderful manner. Its greatest use appears to be in early life, when we are first learning to prattle and speak, at which time it enables the larynx and the ear,— the active and the passive,—to be exactly concordant, and the one to be initiated into the other's modes of action. For since one modification goes by two ways to the same organ, and [after being divided into two] is there again concentrated into one, of course even the smallest discrepancy is observed, and nature instantly checks it, and reduces it to consonance and unity. I used the expression,—by two modes and two ways; one mode is, by the continual propagation of tremor along the course of the membranes; the other is by the air and its propagation, the parts whereof are not continuous, but floating and free, and contiguous to each other. But the subject of the Eustachian tube will be resumed in Part VI., in the Chapter on the Ear.

words, to the threshold and conchæ of the external ear, and there knocks at the door of the tympanum (*c*). Thus the larynx communicates with the bed-chamber of the ear, at once through a clandestine passage or interior path, by continuity, and by an open field or external way, and in the latter case by contiguity. Hence between these organs, compeers and companions in office, there is a perpetual interchange and renewal of concord and correspondence.

359. Both these organs are constructed of little bones, cartilages, and membranes, folded together and accommodated to each other in a wonderful manner; and thus the organic forms of both, differently from those of the other instruments of the senses (*d*), are presented bare and evident within the sphere of ocular vision; so that any mind possessing a right understanding, and educated in the sciences, by following the guidance of anatomy, and accepting the information of the eye, may be instructed to full knowledge respecting the manner in which nature modulates sounds, and disposes them into articulate quantities. There is nothing in acoustics, music, or harmony, be it ever so internal and arcane; there is nothing in the vibra-

(*c*) It seems probable that the sound emitted from the mouth, takes a circle, and apart from the assistance of the tube, enters perhaps more quickly into the ear of an immediate bystander than into that of the speaker himself; although the difference in celerity is imperceptible to our senses.

(*d*) For in the ear there are a number of little bones, formed for the reception of sound and for the further propagation of it when received; such are the malleus, the stapes, the incus, the cochlea and lamina spiralis, and the semicircular canals; the figures and articulations of all of which are conspicuous and well understood: so likewise in the larynx we have the thyroid, cricoid, and arytænoid cartilages, and various ligaments and muscles; the ginglymi and joints of which parts are obvious to the senses. The case is otherwise in the eye, where the humors, with their individual substances, do not reach even the smallest ray of sight, however armed and exalted by the microscope; and the same may be said of the organism in the tongue and in the membrane of the nares; where we indeed see papillæ, but of the manner in which they are inflected and complicated, sight affords us no information.

tions and tremblings of any continuous body, nor in the modifications of any contiguous volume or atmosphere, be it ever so hidden and profound, but nature has here brought it forth from the innermost, gathered it into one, and conferred it upon these two organs (*e*). Here then, for the first time, we are in-

(*e*) In the universal play and circle of nature there is nothing at once more wonderful and more common than modification, whether it occur in the atmospheres of the world, or in continuous, and particularly in elastic substances, as membranes and cartilages, and even in others of a comparatively hard character. Corresponding to modification in the atmospheres, there is a subtle tremble in membranes, and a kind of undulatory vibration in hard bodies; for the one passes into the other,—the modification of the air into the membranes and nerves of the organ of hearing, and the tremble of the larynx into the air. But although nothing is more common than modification, yet nothing is more occult, or appears more complicated and perplexed. Nature presents herself to the senses in her modificatory aspect, not only in sounds and speech, in musical harmonies and musical instruments, but also in optics, and consequently in all those organs that have the faculty of so dividing the rays of modified light, as to represent different colored appearances, that is to say, appearances discriminated by light and shade, and recognizable in this manner. And in truth the other sensations, of smell, taste, and touch, are nothing else than modifications, that run along the nerves and membranes to their origins. Modification, therefore, prevails even in spiritual things; but here its purity and perfection is so great, that, judging according to our senses, nay, according to our very minds, we must pronounce the term modification to be too gross to serve any purpose beyond comparison and analogy. Only take away life and soul from the organic fibres and principles of the animal kingdom, and what remains from sensation is pure modification, such as exists in the auras; or, on the other hand, add life to modification, and the result is sensation. The universal organic body with its membranes and fibres, resembles a kind of harmonious symphony. But to return to sonorous modification, or as it is more rightly termed, modulation:—Nature manifests herself,—she shews what she is,—by modifications alone; into them she has transferred herself, and if we may be allowed the expression, her nature; consequently it is of the last importance to our object to investigate this; for without a knowledge of it we cannot proceed a hair's-breadth by the analytic method, in exploring the causes of things from effects. For

structed by the larynx how nature organizes active powers of this kind, and calls forth, raises and exalts them to the distinct perception of sense, so as to produce infinite varieties of modes.

360. The uses of the larynx are, to open the door for the pulmonic air to pass and repass; to utter sounds, and to render them sharp and clear; and again to inflect these sounds into the notes of singing, or else to articulate them into words (*f*); consequently to undertake and perform the first department of offices in respiration, modulation, and speech; and thus, by the motion of respiration, to infuse a kind of spirit and life into the universal body; by modulation, to do the same for the animal mind, which is affected in this way; and by speech, for the rational or human mind: thus to excite the whole with all the parts, to their proper modes of action. The larynx is of use in the regulation of all these effects. Now in order that it may be an organ capable of producing all the states and varieties in

this reason I have made up my mind to scrutinize diligently the organs of the senses, previously to constructing a doctrine of modifications. Here we are on the mere threshold, for the larynx instructs us only how it modifies; that is, how it gives origin to modifications; not how modification takes place: but it is the ear that receives, formed, as that organ is, to all the states of the modifying power. Nor can we learn these things anywhere more exquisitely than from nature herself in the animal kingdom, where she has built a kind of palace, or reared herself a monument, of the arcana of all the arts and sciences.

(*f*) Merely uttering sound, or sounding, is the most ordinary thing of all, and common to nearly every living creature upon earth: but making the sound canorous, is distinct from the former, and proper to the singer: modulating it again, or inflecting it into various measures, amounts to producing harmony or the form of tunes, according to which form sweetness, agreeableness, or unpleasantness, are predicated of singing; and by which the animal mind is affected in various ways. But articulating sound, or speaking, is something different from the sound and measure of singing, and is brought about by means of a kind of lowered and recitative sound, that remains after the living and elevated shrillness of singing is subtracted or taken away. But these distinctions can only be learnt clearly by the ear, by close attention, and by instituting a comparison in oneself when either singing or speaking.

singing and speech that are possible in nature, it must be possessed of the following endowments: I. It must have acquired the faculty of opening the glottis into all measures, figures and forms whatever, that can be described by the geometric compasses, or summed up by the analytic calculus, (namely, from the line or fissure to the complete circle); consequently, into all possible intermediate curves, both simple, and compounded and mixed in infinite ways. II. It must be able to diminish and enlarge these diversiform apertures of the glottis, that is to say, the diameters of the above-mentioned figures, within stated limits, and by reason of the varied dimension, to dilate the field, and multiply the details of the modifications. III. It must have the power of disposing and conforming the cavity of its tube comprehended by the cartilages, to the whole nature of sound, to the relative size of the aperture of the glottis, and to the correspondent condition of the palate, the tongue, the lips, and the mouth. IV. At the very moment when singing or speaking are intended, the membranes must be put in readiness to receive the sonorous tremblings, and instantly prepared for the proximate series of varieties: and the laryngeal tube, with all the apparatus below and above it, from the lungs to the aperture of the mouth, must suffer itself to be extended or contracted, suitably to every heightening or lowering of the sound. V. Lastly, the larynx must have acquired the power of beginning the sonorous modification at any point whatever, and of determining it whithersoever and in whatsoever quantity it pleases, either through the labial orifice, or through the nares; also of stopping it suddenly in midway, suspending it, and thus breaking it articulately, introducing pauses, taking it up again, continuing and limiting it, according to the articulations and breathing times in speech. VI. In order that the power of performing these offices may subsist in perpetual integrity in its organic parts and membranes, the larynx must renovate them, in such manner and measure as use demands, with an unfailing spring of the most suitable humor (*g*). Let us now consider each of these points separately.

(*g*) This use specially respects the actions of the larynx when it either sings or speaks; but when it only transmits tacitly the breathings

361. I. *The larynx must have acquired the faculty of opening the glottis into all measures, figures and forms whatever, that can be described by the geometric compasses, or summed up by the analytic calculus; namely, from the line or fissure, through all possible intermediate curves, both simple, and compounded and mixed in infinite ways, to the complete circle.* This we are taught by the infinite variety of sound,—of its quantity, of the degrees of that quantity, and of the composition of these degrees (*h*). The

of the lungs, and disposes and adapts itself and the epiglottis, according to the varying entrance of the air, either by the mouth or the nares, and according to its varying quantity,—in this case the action does not seem to belong properly to the organic structure of the cartilaginous larynx. To the uses summarily propounded in the text, we may add one other use; namely, that the larynx also concurs, as a subordinate cause, in the work of eating: of this use we shall speak presently.

(*h*) It is now to be shewn that the larynx, by means of the muscles and the rest of its apparatus, has the power of closing the glottis into a mere fissure, and of expanding it into a complete circle, which two are the extremes of all curved figures; since between the line and the circle exist all geometrical and arithmetical curves, of all orders and classes; namely, ovals, parabolæ and hyperbolæ, of every possible dimension, diameter and kind. The last mentioned of these do not indeed enclose a space, but nevertheless the aperture of the glottis may be disposed on each side in exact accordance to their ordinates and diameters; likewise in accordance to other curves, even to all descriptions of cycloids. That the glottis, by variations of form, produces all varieties possible in sound and perceptible by the ear, may be seen clearly from the case of musical instruments, as pipes, flutes, trumpets, clarions, cornets, horns, and the like, which are played by blowing. In these instruments, the sounds are altered, broken, rendered grave or acute, by the mere variation of the aperture; for when the finger, wandering over the holes, closes up one or more, a different degree of tone comes forth immediately. But not only does the aperture itself vary the degrees of sound, but many other causes concur, as the material of the instrument, its density, softness, elasticity, length, and so forth. The same is the case in the larynx, which is the reason why no two voices have an absolutely similar sound. Perhaps, however, it may be objected, that the dimension of the aperture is of itself sufficient to produce these diversities of sound, as in musical instruments, and that the variation of the form of the aperture contributes very little

proximate and proper parts that describe and vary these diversiform apertures of the glottis, are the two arytænoid cartilages (i), to produce them. But inasmuch as nature constantly aspires to the highest perfection, and inscribes upon the whole of her organism a faculty of infinite variety, so she also inscribes this faculty upon the larynx, and has implanted in it a power of producing all the varieties of modes that are possible in the universe,—particular, general and most general. Not to unfold this matter more deeply, that is to say, from causes, visible effects themselves are quite sufficient to prove it. How numerous the shapes which the very aperture of the mouth assumes when we are singing or speaking!—at one time it is contracted to a fissure, and the voice comes out in its sharpest form, or as a mere hiss; at another time it is expanded into a full circle, when any grave or great sound is to be evolved; or one corner of the mouth is opened more than the other, and a curve of uneven circumference formed, sometimes out of all shape, deriving, in fact, something from the circle, something from the oval, and something from some other figure, inflected and reflected. The same may be said of the velum palati as of the mouth. Now the aperture of the mouth of the lips is correlative or correspondent to that of the glottis, as may be shewn by many considerations. If we desire to speak from positive causes, we must then in the first place explore the air and its modifications, from the form of its parts, and their powers of action. In the present circumscribed arena, we cannot expatiate in that direction; for the subject belongs to a distinct field. Nevertheless for the sake of the better understanding of what follows, it may here be mentioned, that the quantity of sound results from the quantity of the atmospheric volume that vibrates at once, or that is excited simultaneously to a modificatory tremble. But the quality with all its degrees, is owing to the celerity of the vibration; as is very evident from stringed instruments, harps, lyres, symphonies, harpsichords and the like. To these remarks it may be added, that sound is excited in two ways; *First*, immediately by the air itself, which, when set in vibration by the impulses of the mouth, or by various shocks and reverberations, impresses hard bodies with tremors similar to its own, and which bodies, by their concurrent trembling, exalt these tremors till they reach the sensation of hearing, as in trumpets and the like, which are played by mere blowing. *Secondly*, by impetus and impulses made immediately upon hard, and particularly upon elastic bodies, as drums, cords, strings, &c., which impress their tremors upon the contiguous air. That the larynx produces its sounds from both sources will be shewn throughout in what follows.

(i) The arytænoid cartilages form the posterior part of the glottis,

by means of muscles, ligaments, membranes, and glands. The *muscles* that contract it to a mere fissure, are the thyro-arytænoidei (*k*); to these, the cartilages just mentioned lend and apply their own proper powers, by means of their oblique decussating muscles, the ary-arytænoidei (*l*): lastly, but only in a particular manner, by the single arytænoideus or transversalis, which locks or fastens the parts (*m*). The muscles that expand

but by means of muscles and membranes; and by means of their articulation, consequently by means of their contraction and separation, they open and constrict the aperture in diversiform ways, or even close it entirely. The anterior border of the glottis,—that which is opposite to the part just mentioned,—is formed by the epiglottis; which seems, however, in no degree to contribute to the variation of the aperture, but by its inclination and nictitation, only relaxes or stretches the membrane that covers in the anterior border, for it does not appear to be furnished with any articulation or muscle in this situation. Nor do the other cartilages, the thyroid and cricoid, contribute in particular to the variation of the form of this orifice, but only in general, by giving the arytænoid cartilages the power of coming closely together, or diverging more or less widely asunder. No less an effect than the above can possibly result from pieces of cartilage so moveable as the arytænoids.

(*k*) The two thyro-arytænoid muscles arise by very broad beginnings between the thyroid and cricoid cartilages, and contracting as they proceed, go each to the neighboring arytænoid cartilage, and are fixed over nearly the whole of its anterior surface: in some subjects they constitute almost the entire border of the glottis. See Winslow, *Exp. Anat.*, *Tr. de la Teste*, n. 452. The thyro-arytænoid muscles, according to Heister, constringe the glottis; see above, n. 354.

(*l*) These muscles run obliquely from the basis of one arytænoid cartilage to the middle portion of the other, and cross or decussate. Eustachius has represented them admirably in his *Tabul. Anat.*, tab. xviii., fig. 16; and they are finely described by Morgagni [in his *Advers. Anat.* i., n. 28].

(*m*) This muscle runs transversely on the outside from one arytænoid cartilage to the other, directly across the interstice that separates the two, and therefore when its fibres contract, it brings the arytænoid cartilages close together, and shuts the glottis. See Winslow, *Exp. Anat.*, *Tr. de la Teste*, n. 453, 466. From the foregoing considerations it appears, that nature proceeds constantly according to the laws of her order,—that in the present case, in opening and shutting the glottis, she applies different powers, general, singular, and individual

this fissure into a complete round or circle, are the crico-arytænoidei posteriores (*n*); for these draw downwards the two cartilages,—the regulators of the sound,—and together with the crico-arytænoidei laterales (*o*), likewise draw them outwards. From the immensely diverse coöperation of the muscles that close the glottis into a mere fissure, or widen it into a complete circle, we may learn the nature of the action of each when any intermediate curve is to be figured, whether such curve be a conic section, or any other geometric curve, or an arithmetical or cycloidal curve, or a new and compound curve formed of any of these varieties (*p*). The *ligaments* also concur, particularly

or most singular. The general are the thyro-arytænoid muscles; the singular are the ary-arytænoid; and the individual or most singular, are the transverse arytænoid; whether the latter be a single muscle, or whether with Douglas we consider it as two muscles.

(*n*) The crico-arytænoidei posteriores cover nearly the whole posterior surface of the cricoid cartilage, and are separated from each other by only a small tendinous band or fascia. They are inserted in the back part of the base of the arytænoid cartilage of the same side, and when they act, they powerfully draw down these cartilages and separate them from each other, thereby opening the glottis by a kind of general action. "The crico-arytænoidei posteriores," says Winslow, "separate the arytænoid cartilages obliquely backwards, and at the same time stretch or extend the sides of the glottis; hence they do not dilate the glottis in the same manner as the crico-arytænoidei laterales." *(Ibid.*, n. 464.) See Heister above, n. 354, and Eustachius, *Tabul. Andt.*, tab. xviii., fig. 16.

(*o*) These muscles, arising from the side of the broad part of the cricoid cartilage, and inserted in the lower part of the side of the arytænoid cartilages, draw the latter obliquely forwards and downwards. See Heister above, n. 354, and Winslow, *Op. et Tract. Cit.*, n. 451, 464.

(*p*) From the situation, insertion, and consequent mode of action of these muscles, it is very evident that there is no possible figure that they may not produce by the varied application of their forces; for they come from all directions, and flow in at all angles; and this is the case both with those muscles that shut the aperture, and with those that open it. Every fibre has its own particular power of action, just as in all the other muscles of the body; so that there are almost as many distinct muscles as fibres, and which muscles can act separately and can

those which connect the arytænoid cartilages to the thyroid and cricoid, and to the epiglottis (*q*): they are in a manner guards and regulators, that constantly restore the state, form, and limits of the larynx and glottis, when altered by the voluntary actions, to the natural standard, and prevent the parts from throwing themselves beyond the limit prescribed by nature; and they are in a manner bonds, that compel the particular motions of the cartilages and muscles to maintain an exact correspondence with the general motions of the tongue, the os-hyoides, the palate, and the epiglottis (*r*). The *membranes* assist in like manner,—the membranes which are continued from the palate, and invest and cover all the parts; for by the mediation of the epiglottis, and its arthrodial movement, and if we may use the word, its nictitation, they accommodate themselves exactly to the modes of the muscular fibres (*s*). So also the arytænoid

act conjointly; therefore in complete accordance to every idea and mode of the directing or determinant power.

(*q*) Respecting these ligaments, see Winslow above, n. 355. The thyro-arytænoid ligaments, superior and inferior [antica et postica], between which lie the orifices of the ventricles of the larynx, are exhibited very distinctly by Morgagni. (*Advers. Anat.* i., tab. ii., fig. 2, 3.) But we cannot predicate the same of the ligaments as of the muscles; for they have no living power of action, but only suffer themselves to be acted upon by the muscles, and react proportionably; restoring the order or nexus of parts every time the muscles infringe or strain it in any shape or way; for the voluntary actions are constantly extruding parts from their natural places, and therefore ligaments are required to restore them: such is the perpetual contention between nature and the will.

(*r*) We shall speak of these subjects in the next paragraph.

(*s*) This is evident from a mere description of the extension and continuation of this membrane. "The ligament of the epiglottis," says Verheyen, "which forms the sides of the fissure, arises from the lining of the fauces. It is however double, and one layer covers the convex, the other the concave, surface of the epiglottis; after which it runs backwards along both sides of the fissure, and invests the arytænoid cartilages and the adjacent glands, filling all their interstices; and thus renders the border of the fissure continuous and solid." (*Corp. Hum. Anat.*, tract. iii., cap. xi.)

glands, which are situated posteriorly on the lip of the fissure, and afford a soft passage for the sounds (*t*). All these things, by the stupendous ingenuity of nature, lend their united aid in all the momenta of the motion, and while they form the aperture of the glottis, they also form the sound itself in the most complete agreement with the laws of musical harmony.

362. II. *The larynx must be able to diminish and enlarge these diversiform apertures of the glottis, that is to say, the diameters of the above-mentioned figures, within stated limits, and by reason of the varied dimension, to dilate the field, and multiply the details of the modifications* (*u*). For in proportion as the

(*t*) These glands are described and delineated by Morgagni. "The oblique portion of the fissure," says he, "is formed by the two arytænoid cartilages, and also by the two long crura of the arytænoid glands; consequently this part of the glottis is double" (n. 356). Verheyen mentions another gland, which he describes as "lying upon the superior border of the cricoid cartilage, between the two arytænoid cartilages." (*Op. Cit.*, tract. iii., cap. xi.) These glands cause the posterior part of the glottis to ascend obliquely, and thus give it the power of diversiform dilatation, agreeably to the proposition we have laid down. See n. 360.

(*u*) It is one thing to unfold or bend the aperture into different shapes or forms, and another to enlarge or contract these same forms in a general manner. By means of the latter power a variety of dimension, greater or smaller, is communicated and superadded to every possible form: the former power respects only quality, but the latter, continuous quantity or magnitude. In a given magnitude, all diversities of form or aperture may likewise be produced, but differences result therefrom, like differences of quantity, that is, the sounds acquire gravity, grossness, manliness; and as there are infinite differences of quality, so there are also infinite degrees of quantity: the latter differences or degrees might in a certain sense be termed the quantities of quality; excepting that quantity in sounds also respects their altitude or intensity. Nature has allowed and assigned to every larynx its peculiar limits, beyond which the area or circle of the glottis cannot be enlarged; she has also bestowed the power of expanding these natural limits to certain dimensions; which is the reason why some persons have a natural gravity of voice, such as we term manly, and others again a tenuity and slenderness of voice of a feminine character; and this according to the extension of limits allowed by nature.

opening of the glottis is made round and large, in the same proportion the voice becomes full and grave; and in proportion as the opening of the glottis is narrow and contracted, in the same proportion the voice becomes sharp and small. Therefore, in order to shape forth all, yea, even infinite varieties, the power of enlarging and contracting the given forms *ad libitum*, must be superinduced upon the power of varying the forms: whereby an infinite variety is multiplied again by another variety also infinite (*x*). The proper muscles of the larynx are not so instrumental in producing these varieties of dimension, as the tongue itself and the os-hyoides (*y*); consequently, as their muscles,

(*x*) Let us suppose an extension of limits to a certain given diameter; of course we suppose at the same time an infinite difference between the greatest and least diameters, which, multiplied by the former infinite variety, yields differences that exceed all amounts within our calculation.

(*y*) For this is an accessory not to be confounded with the modifiability of sound; nor is the variation here alluded to produced by the proper muscles of the larynx; being only a common change of state, under which the other changes, essential and proper, and the qualities, are carried on in the same manner as if they were not present. Indeed, singular states are in no way changed by the superinduction of general states; as we see from the case of particular undulations in one general undulation, and of sonorous modifications; or if the illustration be preferred, visual modifications, when the general modification, light for example, is varied: for the particular is not aware of the general change, unless a higher power be present to reflect upon the variation of particulars resulting therefrom. The same remarks may be applied to the blood and the humors of the body, which permeate their vessels and passages, whether the corporeal system generally be enlarged or contracted; also, to the heart, which drives its blood through the common vessels of the body, and through its own proper vessels, whether it be expanded or contracted, adult or infantine. In like manner we regulate the sounds with our fingers, whether the pipe be large or small. So in universal nature,—wherever a common state is superinduced upon minute and most particular motions: consequently also in the larynx, where the minute particular motions remain the same through all its variations of size: which, indeed, is the reason why these common variations are most distinct from the singular variations, and in consequence are not dependent upon the proper muscular fibres, but upon more

namely, the sterno-hyoidei, stylo-hyoidei, omo-hyoidei, mylo-hyoidei, and genio-hyoidei; and the four lingual muscles, namely, the stylo-glossi, cerato-glossi, basio-glossi, and mylo-glossi; and also the digastric muscles of the lower jaw (*z*). But all these are remote causes; the action of the tongue upon the epiglottis by means of the epiglottico-lingual ligament, is a more direct cause; and the action of the epiglottis upon the arytænoid cartilages, by means of the ligaments, is the proximate cause of the effect (*a*); with which also concurs, as an associate

remote fibres extraneous to the larynx, and thus, in a general manner, upon the ligaments.

(*z*) That all these muscles, with infinite variety, act upon the tongue, and by means of the tongue upon the epiglottis, and by means of the epiglottis upon the arytænoid cartilages, thus that they act remotely, may be known clearly from their situation and connexion, as well as from touch and sight. That the action of these muscles extends to the larynx, is shewn by Winslow in his *Exp. Anat.*, *Tr. de la Teste*, n. 443, 444; where to the muscles I have enumerated he adds the thyro-pharyngæi and crico-pharyngæi; of the coöperation of which we shall speak presently.

(*a*) There is one very broad ligament which is continued from the middle of the root of the tongue to the dorsum of the epiglottis, and adapts this moveable and lid-like portion of the larynx to all the flexures, retractions, extensions, and foldings of the tongue: so that when the tongue is drawn back towards its root, as during all loud vociferation, and the utterance of gross or base sounds, or of the vowels *o* or *u*, then the very base of the epiglottis is pushed in, and its extended portion bent backwards. When, therefore, the epiglottis is pushed in and relaxed, then the arytænoid cartilages are also forced backwards, or rather they retract spontaneously, so that they are further distant from the median fissure: this is the first cause of the common enlargement of the orifice. Respecting the ligament above alluded to, Winslow says, "The epiglottis has likewise two lateral ligaments by which it is connected to the arytænoid cartilages, all the way to their points or cornua. It has also a membranous ligament, which running along the middle of its anterior or convex side, ties it to the root or base of the tongue" (n. 355). The arytænoid cartilages have two apices to which the above ligaments are attached; these apices are very small, moveable, and almost separable from the bodies of the cartilages; the reason of which appears to be, that the tongue is very frequently bent back-

proximate cause, the action of the os-hyoides upon the thyroid cartilage by means of the ligaments passing between the two (*b*);

wards during the operation of eating, and at this time makes constant use of these arytænoid capitula, and this when speech is not going on, that is to say, when the larynx is unmoved: such would seem to be the reason of the flexibility of these little appendages. "In some subjects," says Winslow, "[the cornicula of the arytænoid cartilages] are very moveable, appearing like true appendices, and easily separable from the rest, as I demonstrated in my private courses about eight years ago" (n. 355).

(*b*) The thyroid cartilage has four cornua, two running upwards, termed the superior cornua, and two running downwards, termed the inferior cornua: these cornua merely serve as fulcra for the ligaments; the two superior for the ligaments between the thyroid cartilage and the os-hyoides; the two inferior for the ligaments between the thyroid and cricoid cartilages. These are the most considerable of all the ligaments of the larynx, and the cornua of this cartilaginous ægis or shield are constructed and put forth entirely for them and their uses: which is a sufficiently clear proof that these ligaments make some common cause; for otherwise they might have been simply inserted in the side of the thyroid cartilage, without the apparatus of these fourfold processes. From the situation and connexion of these ligaments, it is plain that every time the tongue draws itself back and retracts the os-hyoides, it also drives inwards the superior part of the thyroid cartilage and the root of the epiglottis: so that the arytænoid cartilages are removed from the centre of the glottis, (for they are placed and articulated upon two protuberances in the cricoid cartilage,) and thus they acquire the power of producing enlarged diversiform apertures. By carefully examining this contrivance, we observe that the approximation or removal of the thyroid cartilage contributes in no degree to the enlargement of the glottis, but only that its approximation gives the arytænoid cartilages the power of removing themselves, and thus describing larger forms; and this in three ways. *Firstly*, by drawing inwards at the same time the root of the epiglottis itself, so that the arytæno-epiglottidean ligaments being relaxed, the arytænoid cartilages themselves are also relaxed. *Secondly*, by the thyro-arytænoid ligaments in like manner giving in. *Thirdly*, by the thyroid cartilage, by its intropression, drawing forwards the inferior part of the cricoid, which cartilage, by this adduction, greatly enlarges the capacity of the glottis, namely, by driving back the arytænoid cartilages, which are seated upon its posterior border. Inasmuch as this is purely mechanical, therefore we may all infer the

which ligaments again, in their turn, are assisted by the ligamentary thyro-arytænoid and crico-thyroid cords (*c*), and by the other more individual or particular ligaments acting under them (*d*). By all these means, the boundary, diameter, and cir-

effect, provided we have an idea of the connexion of the parts. "The apices of the superior cornua [of the thyroid cartilage]," says Winslow, "are fixed to the posterior extremities of the great cornua of the os-hyoides, by slender round ligaments, about a quarter of an inch in length. . . . The thyroid is likewise connected to the os-hyoides by a short, broad, strong ligament, one end of which is inserted in the superior notch of the cartilage, and the other in the lower edge of the base of the bone" (n. 355). In the middle of the ligament running between the superior cornua of the thyroid cartilage and the os-hyoides, we sometimes find a cartilaginous nodule, which serves as it seems for the same purpose as the little moveable heads of the arytænoid cartilages mentioned just above; it provides, namely, that during eating, the larynx and the thyroid cartilage remaining unmoved, the os-hyoides may be repeatedly pushed backward, without the thyroid cartilage being drawn back with it.

(*c*) When the superior part of the thyroid cartilage is driven inwards, its inferior part is necessarily pushed in the contrary direction, or outwards, consequently also the inferior or anterior part of the cricoid; so the superior and posterior parts of the cricoid, upon which are situated the arytænoid cartilages, are driven outwards, and thus the space is enlarged which those cartilages enclose behind, and by which the glottis is formed. Respecting the crico-thyroid ligaments, Winslow says, "The cricoid cartilage is connected to the lower part of the thyroid by a strong ligament, and round about its lateral articulations, by the ligaments already mentioned, to the inferior cornua of that cartilage" (n. 355).

(*d*) Besides these primary ligaments there are also others, which may properly be termed secondary, inasmuch as they are individual or singular, and convey and propagate the general action all the way to the least joints or parts. These ligaments are stretched between the epiglottis and the thyroid cartilage, at the middle notch of the latter, where a kind of triangular space is formed: also between the thyroid and arytænoid cartilages, on the concave surface; and there are others besides, respecting which we refer the reader to the descriptions and plates of our Authors. These peculiar and internal ligaments are admirably figured by Verheyen. (*Corp. Hum. Anat.*, tab. xxii.)

cumference of the laryngeal tube, and in the same proportion all the apertures of the glottis, whatever be their form and howsoever they be varied by the arytænoid cartilages, are enlarged, and the sounds consequently rendered graver. That such is the case, we may readily convince ourselves by the sense of touch, if we apply a finger to the larynx, and specifically to the cricoid and thyroid cartilages, or the pomum Adami, while the larynx is in the act of singing or speaking, and the tongue is either putting itself forward or being retracted.

363. III. *The larynx must have the power of disposing and conforming the cavity of its tube comprehended by the cartilages, to the whole nature of sound, to the relative size of the aperture of the glottis, and to the correspondent condition of the palate, the tongue, the lips, and the mouth* (*e*). For the universal mechanism of the mouth, that is to say, the lips, the tongue, the velum palati, the uvula, and the larynx, and with the larynx not only the glottis, but the whole length of the tube, and even the trachea, the bronchia, and the innermost lungs, concur and conspire, in the most harmonious and astonishing manner, to the production of every tone; hence it may readily be seen of what innumerable little modes every mode is composed. In the production of this effect, the laryngeal passage concurs with the tongue, by means of the ligamentary connexion between the two, as

(*e*) The whole interior apparatus of the larynx must necessarily concur to the formation of the orifice of the glottis, in the same manner as not only the muscles of the lips, but also the cheeks, the temples, the lower jaw, the tongue, the mouth, and the palate, concur to the opening of the mouth; all of which at length produce the ultimate effect in the orifice. Throughout nature there is always a chain of efficient causes, one under another in manifold subordination, which chain not only produces, but even constitutes the effect; and of these causes, moreover, there is a unanimous conspiring and correspondence; thus of course there is the same conspiring and correspondence of the entire passage of the larynx with its extremities. But this passage is circumscribed by hard cartilages, and notwithstanding is variable, by the assistance of its lining membrane, and particularly of the ventricles, (as the palate, in itself osseous, is variable by means of the velum): not to dwell upon the power of elongation and contraction possessed by the tube, and of which we shall speak in the next paragraph.

above (*f*); with the velum palati, by the continuous membrane that invests the parietes of the tube within and without (*g*); with the trachea and its first rings, by the cricoid ligaments affixed thereto (*h*); with the inner margin of the glottis, by the sinuses or ventricles, which adapt the calibre of the tube to the aperture of the glottis (*i*).

364. IV. *At the very moment when singing or speaking are intended, the membranes must be put in readiness to receive the sonorous tremblings, and instantly prepared for the proximate series of varieties.* This is evident from all continuous sounds, that is, from all the modulatory sounds of singing; and from all contiguous sounds, that is, from all the articulate sounds of speech. For during the utterance of such sounds, a manifest tremor invades the membranes, cartilages, and bones; particularly the cavernous and laminated bones,—those which are fitted together in the form of leaves, adhere closely to the periostea and perichondria, and are of an elastic nature. This tremor, emanating from the trachea and the larynx, diffuses itself, and runs like lightning, over all points of the palate, the nose, the

(*f*) See above, note (*a*).

(*g*) See the citation from Verheyen, in note (*s*).

(*h*) We shall speak of these ligaments in the next paragraph.

(*i*) The ventricles of the larynx perform many uses, that is to say, they not only adapt and accommodate the capacity of the laryngeal tube to the diversiform aperture of the glottis, but they also multiply the sonorous tremors or modifications about the orifice, where these tremors issue forth; and moreover, they stop the sound itself in midway, as is perpetually required in speaking; wherefore we shall have a more fit opportunity for treating of them in what follows. Meanwhile it seems probable that they may perform the same use in the laryngeal tube, close under the rima glottidis, as the velum palati performs in the fauces. But as I do not see how they can be expanded and filled by the air, excepting at the time when the epiglottis is driven back, and with it the superior part of the thyroid cartilage, and the thyro-arytænoid ligaments and muscles, therefore I do not at present venture to ascribe to them this use as one which they have absolutely and continually. Certain it is, that when they are kept expanded, they close the narrow strait; but whether this can be brought about in any other way than by the retention of the breath, and the simultaneous retroaction of the tongue, I am not now able to determine.

temples, and the cranium,—wherever the parts are continued (*k*). The fact that the membranes are brought suddenly, by some wonderful nature and art, into a power of receiving tremors, and into the modificatory state of sound, will be conspicuously evident, if we merely reflect upon, and apply our thoughts to, the alteration of state in the lungs, the trachea, and the larynx, at the moment that intervenes between the last point of respiration and the first point of singing or vociferation; for at this time an external and voluntary action upon the lungs and air pipes, succeeds instantaneously in the place of the internal and natural action, pure or mixed (*l*): and by this new action the

(*k*) This is evident from many phenomena, most manifestly so in sounds of which the tremor is powerful enough to reach the sense of touch; as in those that are at once grave and loud, that is, in great sounds, the tremble of which sensibly pervades the very bones and marrows, as well as other continuous and hard bodies. Nothing is more wonderful than the propagation of tremors: sonorous modifications, almost in the same manner as visual modifications, penetrate the auras, and pass into even the very hardest substances, and into all their contiguous parts; so much so, that the mere tremor or rumbling of a wheel, or the clatter of a horse's hoofs, sometimes affects and shakes whole houses, mansions, palaces, neighborhoods and mountains, until the doors, roofs and windows vibrate visibly; nay, intervening lakes convey the tremor imparted to them, swift-footed and winged as it were, from bank to bank. The tremors of a purer nature, of which we can be rendered conscious only by a sense adequate thereto, travel still more readily, rapidly and perfectly. It is plain, therefore, that the sonorous tremor, wherever in the body commenced, whether in the trachea, or in the larynx, or elsewhere, can never end until it has pervaded the whole system, or the parts corresponding to the whole;—until, in fact, it arrives in the end and beginning of all things: and that wherever it penetrates, it is propagated onwards along the organism presented to it: which is the reason why the sound, distinctly discriminated, is forwarded by the ear alone to the beginnings or principles of all the sensoria.

(*l*) We observe by reflexion, that as soon as ever we begin to sing or speak, we stop the natural act of respiration, and hold the breath, to be duly dispensed for the offices of singing and speaking; also that we do not then allow the breath of the lungs to flow out freely and naturally; but the mind and will taking the initiative, we determine operations not only upon the muscles of the larynx, but also upon the

air is forced out, and dispensed with exact economy, answerably to the entire series of what the mind is about to utter. At this point of time we also perceive an alteration in the direction of the air, namely, to the parietes; in fact, a species of incidence and reverberation; and a disposition of the membrane to receive, and a preparation or endeavor to tremble (*m*). The same thing obtains evidently in all the sensoria, both in the external sensoria, of sight, hearing, smell, taste, and touch; and in the internal sensoria, as in the apperception and determination of these, and in thought itself; also in all the motorial organs, or what amounts to the same thing, in every voluntary action (*n*).

most general muscles of the chest; so that a kind of extrinsic and voluntary action, succeeds in the place of the intrinsic or natural action. Respiration, as we know, is both natural and voluntary; consequently of a mixed kind during the day. The will acts upon its muscles, which are the external muscles of the thorax, but not upon the vesicles of the lungs; both these actions must concur in order to the existence of the respiratory act. But in modulation and speech the one seems to be separated from the other, so that the voluntary action alone prevails. In these cases the air passes out through the bronchia and trachea, by means of external compression, and therefore not so ordinately and mildly [as during the involuntary actions]; it is forced from side to side of the tube; and in the intervals between the joints, it is thrown and repercussed or reverberated against the cartilaginous circles and angles; and in this manner excites the membrane. As soon as any pause or breathing time divides the series, that is to say, intervenes, the action again commences from the innermost parts of the lungs, and the outermost action is accommodated thereto. If then we wish to define the state of speaking and singing, it may be described as the voluntary act separated from the natural act, the effect of which is, the impulse o the air upon the membranes of the parietes, which thus disposed for trembling, receive the impulse as the sensorial organs receive touch. But more will be said on these subjects in the following Chapter, when we come to treat of the Trachea.

(*m*) See note (*l*) immediately above.

(*n*) We term this, stretching or tension; for the very nerves are stretched to receive the touches or forces; such tension being bestowed, as an adjunct, upon every sensorial organ. I am not now speaking of the application of the organs to objects by means of the muscles, as of the eye, the ear, the tongue, &c.; but of a certain disposition of the

Thus when the membrane is made to tremble,—as the reed of a pipe by blowing, or the string of a harp by striking,—it carries with it into an accordant tremble the adjoining parts, and by continuity the remote parts, both membranous and ligamentary, cartilaginous and osseous, as well as the passing and circumambient air, and the very breath of respiration (*o*): in this way sound is produced, which flowing and flying onwards, is continually enlarged and increased in the way, up to a degree adequate to the sense of hearing. For this end the sound, like the above sensitive membrane, is continued from the innermost recesses of the lungs, through the bronchia, the trachea, the larynx, the palate, the tongue, the cheeks, the gums, the cavities of the nares, the turbinated bones, the sinuses of the cranium, the cells of the petrous portions of the temporal bones;

fibres, whereby they are most intently adapted to receive sensations, and of an exaltation of their acumen, and such a disposition, that they receive distinctly the modifications which come to them, and convey them distinctly to the general sensorium. We see the same thing in the determination of every action, and still more sensibly in internal sensations, when we direct the ear with great attention to any person's discourse. That the same tension exists also at the very same moment in the larynx and trachea, when they are determined to the act of speech, may be perceived by every one from himself better than from any description. See n. 400.

(*o*) It is very evident from natural proofs of a purely physical kind, that a single thread or even the finest filament is sufficient to convey and transfer the tremble of one body to another, to which the former is connected. A bell sounds quite distinctly in the vacuum of an air-pump, provided it hang from the glass by a slender thread, but not if it be altogether disconnected. A string fixed by one extremity to a harp, or to any other instrument with a large belly, and held by the other between the teeth, conveys the sound of the instrument loudly into the ear; and so in other instances. From these and a multitude of phenomena of this class, we may infer, that the tension of the sonorous membrane of the trachea and larynx, is originally and primarily dependent upon the nervous fibres inserted into it; and that when these are set into a tremble, the whole sheet of membrane is carried into a similar tremble; and with the membrane, the whole of the cartilage, and so on: thus the sound increases, beginning from the smallest origin.

and from these, by a short cut, through the Eustachian tube into the ear; and from all these confusedly into the two meninges; but from the ear distinctly also through the nervous fibres to the general sensorium of the cerebrum; that is to say, to its cortical substance (*p*). For this end, also, the organic parts of the larynx are cartilaginous, elastic, excavated, and spongy (*q*); and moreover, there are two membranous bottles or

(*p*) This is principally due to the pituitary membrane, which is continued from the cavities of the nares, not only into the pharynx and larynx, but also into the frontal, sphenoidal and maxillary sinuses, and even to the dura and pia mater, as may be seen in the preceding Chapter, on the Nose. The secondary use of the continuation of this membrane seems to be, to propagate the sonorous tremblings all over the cranium, as well as to both the membranes of the cerebrum, and thus to equip, sandal or wing the sound: for unless the whole of the cranium sounds together, the tremble cannot possibly be raised to the measure and sphere of the sense of hearing; as neither can it be in musical instruments unless the strings are fixed to a contremulous and elastic belly, which thus sounds in unison with the strings by a general tremble. The sound of a fiddle-string becomes loud exactly in proportion to the consonance of the large body to which it is connected. The whole cranium serves as a kind of belly to this instrument; for without its concurrent trembling, the fibres alone would be altogether unequal to raising the sound to our degeee of sensation.

(*q*) The sponginess of the petrous and temporal bones will be treated of in our Chapter on the Organ of Hearing. Morgagni mentions a similar sponginess in the cartilages of the larynx, stating that he has found "a number of cells inside their substance, in the thyroid, at the sides particularly, but in the cricoid, at the posterior part," and adding, that he has "often seen these cells filled with a medullary substance" (n. 356). Likewise in the arytænoid cartilages, according to the Figures of the same author. (*Advers. Anat.*, i., tab. ii., fig. 6.) The more delicately foliaceous the cartilages and bones, the more elastic they are, and the better accommodated to every little vibration; as we see exemplified in the little bones of the ear, the cochlea, the lamina spiralis, and the rest; for every corpuscule receives the impulses of objects according to its degree of elasticity, and returns the same without loss: which is the reason why the larynx begins to be deprived of its acumen and distinct life as old age comes on; the cartilages ossifying and losing their elasticity. "Nothing has been more common," says

sinuses at the first door of the issuing sound,—at the threshold of the glottis (*r*). *The laryngeal tube, with all the apparatus below and above it, from the lungs to the aperture of the mouth, must suffer itself to be extended or contracted, suitably to every heightening or lowering of the sound;* namely, in order to give forth its infinite variety of degrees of intensity, consequently, of altitude (*s*); for sound is raised and heightened in proportion as the membrane is stretched, or the tube extended; which is

Morgagni, "in my dissections of the larynx, than to find the thyroid and cricoid cartilages of old subjects, either osseous, or in the process of becoming so" (n. 356).

(*r*) When the ventricles of the larynx are distended with air, they seem to have the power of performing this use; for in order that the sonorous tremor may be exalted at the very outlet, that is to say, in the glottis, it is of the greatest consequence that when thus raised to the highest degree, it should come forth into this field of the palate, and be diffused on all sides: wherefore the ventricles are so placed, and so inserted under the rima glottidis, that the whole of every tremor taken up by them, is propagated to the rima itself, and at the same time to the ligaments that go to the os-hyoides, and is effused over the adjacent parts in all directions. But I cannot ascribe the origin of sound to the ventricles, both because they are not constantly in a state of expansion, and because we may clearly observe in our own persons, that sound has its origin, at will, or according to national habit, at one time considerably below the larynx, at another time within it, and sometimes even in the palate itself, as I shall have occasion to explain in the course of the present paragraph, and also in the next chapter. Still less can I admit that the ventricles give forth a hissing sound by their compression, since in this human organ sound arises, not as in pipes, flutes and trumpets, by the intrusion of the air into the lips of the instrument, but by the direction of the air towards the membrane, which being stricken thereby begins to tremble, and soon communicates to the air a concurrent tremble.

(*s*) It is one thing to modify sound, that is, to render it grave or acute, (which we have described as being effected by the variation of the mouth of the glottis;) and it is another thing to render sound, whatever be its mode, high or low, strong or weak. Shouting is produced by the highest expressions of sound; but whispering, or tacit speech, as when we speak in another person's ear, by the contrary. All who are acquainted with music know perfectly well, that the sound

effected by means of the sterno-thyroid (t) and hyo-thyroid muscles (u); also by the raising and laying back of the epiglottis; and by the contraction of the trachea by means of the muscles (x); and subsequently, by the [contraction of the] cricoid cartilage by means of the ligaments (y). On the other hand,

is lowered when the string is relaxed, and heightened when the string is stretched.

(t) The sterno-thyroid muscles are like broad bands; arising from the internal or posterior surface of the sternum, sometimes also from the neighboring part of the clavicle, and of the first rib, they ascend along the neck and the trachea all the way to the thyroid cartilage, and are inserted into its base and sides: in their ascent they are covered by the sterno-hyoid muscles. When they act by the contraction of their fibres, they draw down the thyroid cartilage towards the trachea; consequently when the trachea is contracted, the whole tube of the larynx at once, as far as possible, is simultaneously extended. Thus the entire larynx seems not only to be drawn down from its place, but also to be in a measure elongated.

(u) The hyo-thyroid muscles, connected by one extremity to the base and to the neighboring part of the cornu of the os-hyoides, by the other, to the thyroid cartilage near its base, interweave their fibres with those of the sterno-thyroid muscles. They elevate the thyroid cartilage and separate it from the cricoid; consequently when the trachea contracts its rings, the laryngeal tube is a little elongated, and the membrane which invests the passage is stretched. But these two muscles seem to perform not only this use, but also a still more important use in the operation of eating, namely, by drawing the larynx up and down, and thus adapting it to the modes of the pharynx and œsophagus in swallowing.

(x) Respecting the muscles of the Trachea see the next Chapter.

(y) The cricoid cartilage has ligaments whereby it is connected not only to the thyroid, but also to the rings of the trachea. "Its base," says Winslow, "is attached to the first cartilaginous ring of the trachea, by a ligament exactly like those by which the other rings of the trachea are connected together. The membranous or posterior part of the trachea is likewise connected to the posterior part of the base of the cricoid cartilage" (n. 355). From the ligaments that connect the thyroid and cricoid cartilages, it is evident that the cricoid is drawn downwards to the trachea, nearly every time the thyroid is drawn down by the sterno-thyroid muscle; shewing that it is almost necessary for the thyroid to be relaxed, in order for the cricoid to descend.

the membrane is relaxed when the tube is contracted, which happens when the before-mentioned muscles relax, when the epiglottis bends down to the fissure of the glottis, and the trachea returns towards the cricoid cartilage; to which parts the ventricles of the larynx, as the common regulators of the tension of this membrane, close beneath the fissure, appear to afford very considerable assistance, serving by their expansion to produce the tension of the membrane, and by their constriction to produce its relaxation (*z*); and to all these, the muscles of the chest, and the hyoidei, linguales and palatini, lend and minister a general assistance.

365. V. *The larynx must have acquired the power of beginning the sonorous modification at any point whatever,* so as to

(*z*) As the aperture of the mouth may be formed, opened and contracted variously by the diverse application of the tongue, and drawing down of the lower jaw; and the aperture of the palate, by the diverse folding, extension and constriction of the velum,—so may the aperture of the glottis by the membranous ventricles or sinuses; by which means there is a correspondence between the apertures of the mouth, of the palate and of the glottis, particularly in speech, when the pauses or breathing times are very numerous, and every time these happen, the ventricles may be variously expanded or relaxed. Every expansion and relaxation of the ventricles is communicated ultimately to the membrane that lines the laryngeal passage, for the ventricles are themselves composed of that very membrane. "They are chiefly formed," says Winslow, "by a continuation of the internal membrane of the larynx" (n. 355). Consequently when they are expanded, the membrane of the passage is drawn to them, and the contrary happens when they are relaxed. Thus they seem to deserve the title of general regulators or tensors of the sonorous membrane of the larynx itself; like as in musical instruments, of which the membranes, (as in the case of the drum,) or strings, require to be tightened or slackened by means of regulators or tensors. On this subject Lancisi says in his notes to Eustachius, (*Tabul. Anat.*, tab. xviii., fig. 25.) "Nor do the muscles of the thyroid cartilage serve for modulating the voice, only by compressing the dorsum of the ventricles, but also in many other ways, by changing the shape of the whole internal cavity of the larynx; for if the same thyroid muscles coöperate with the arytænoid muscles, it is scarcely possible that the figure of the cavity comprehended between them should not in some measure be changed."

give the first impulse to the air wheresoever it pleases,—in the trachea, either near the lungs, or near the larynx; or in the larynx itself, high up, or low down; or in any part of the palate. That the larynx has this power, is very conspicuous, (if we pay attention to all the circumstances,) from national peculiarities of speech, from the abnormal speech of particular persons (*a*), as well as from our own speech as determined by the character of the words we use, or called forth in obedience to the will (*b*). *The larynx must also have the power of deter-*

(*a*) There is the greatest diversity in the speech of different nations, both with respect to the origin of the sound, and to its direction and termination; to say nothing of the complication and heaping together of many sounds. With respect to origin, some persons draw out the beginnings of sounds from the deepest source,—from the very bronchia of the lungs, and extract and eructate them in the manner of sobs or sighs from the lowest parts; others speak very softly, from the trachea, close under the larynx, and others again even speak in the fauces. Respecting ventriloquists, as they are called, and respecting loquela pythica, we refer the reader to the records of natural history. There are also numerous instances in which words are brought almost from the mouth, and thus have an obscure and pultaceous character. In fact, if we experiment for ourselves, and bring to the task some natural power, improved by practice, we shall have proof positive of these assertions. To this we may add, as a proof from reason, that if a sonorous membrane admit of tension in one part, it must also admit of tension in another; wherefore this depends entirely upon the determination of the air, whereby it impinges upon the sides in different situations; just as we have the choice of exciting one set or another of the fibres of a muscle or muscles, which can produce together this or that effect.

(*b*) For if by means of the muscles of the lungs and trachea, we have the power of extracting and uprooting our speech from a deeper source, as by reflexion upon that act appears to be the case, then by the compression of the bronchia and of the lowest part of the trachea, and by the slanting of their angles, we may be able to produce a reverberation of the air; so that the sonorous tremor begun at the bottom, creeps up into the larynx, where it is formed and articulated into the distinct notes of sound, or divisions of the voice. The same may be said if we are able, diverting from the ordinary and natural way, to evoke the sound of the voice from the palate itself, the glottis being in a manner closed, but which sound will in this case be obscure, indis-

mining the same modification, whithersoever and in whatsoever quantity it pleases, either through the labial orifice or through the nares. This power is conferred upon it by the coöperation of many instruments, namely, of the epiglottis (*c*), of the velum palati, with the concurrence of the uvula (*d*), of the tongue, and

tinct and harsh. This may be proved by every one who will take the trouble to consult his own experience upon the subjects now under consideration. For there is nothing more than a direction of the air against some part of the side of the membrane, stretched and tightened by means of the voluntary muscles, to receive the tremor of the sounds.

(*c*) The proximate cause of the determination of the sound or sonorous air, appears to be the epiglottis, which prolonged continuously from the anterior border of the glottis, naturally carries off along its concave surface the sonorous air, as well as the respiratory air itself, towards the cavities of the nares; but which is not the case if the epiglottis be inclined or laid back towards the cavity of the mouth, over the surface of the tongue. The epiglottis itself is likewise cartilaginous, and covered by the same sonorous membrane; consequently it continues the tremors, and communicates them thus continued to the escaping air. It is important to bear in mind, that the tremor of the membrane or cartilages is not the proximate cause of sound, but the tremor of the air itself, which is excited to a concurrent tremble by the membranes and cartilaginous springs. So in stringed instruments, the strings or cords are not the proximate causes of the sound, but the air itself, which is carried into a concurrent tremble by means of the strings. The modification of the air alone affects the organ of hearing, and shakes the semispiral membrane of the cochlea in different ways; not so the tremor itself; unless the latter passed into the winged and light-footed air, no sensation could be produced. Consequently, as I before advised the reader, the principle of sound as existing in the animal kingdom is twofold; *first*, the air impinges upon a membrane capable of trembling concurrently with itself; and *secondly*, the membrane imparts its tremble to the air; so that the membrane and the air make common cause; and in this way, moreover, the purely respiratory air is converted into sound. Hence the animal harmonic instrument resembles not only musical instruments that are played by blowing, as pipes, trumpets, clarions, but also those that are played by striking, as harps and lyres.

(*d*) We treated in the last Chapter of the velum palati, and of its applicability to the smallest point of variation in speech, respiration and eating; as demonstrated experimentally by Boerhaave; and we

of the orifice of the lips. *Lastly, the larynx must have the power of stopping the modification suddenly in midway,* by closing the path, or intercepting the passage, as the sound is issuing; by the opposition of the tongue, preventing its escape through the orifice of the lips; by the folding of the velum palati, preventing its escape through the nasal cavities; and by the interposition of the ventricles of the larynx, preventing its escape through the glottis (*e*). Were it not for this threefold power and inter-

there shewed, that its power of accommodating itself momentarily to all these states is principally derived from the uvula. Thus according to the canopying and direction of the velum, we have the power of determining the measured air, or the sound that accompanies it, either into the cavity of the mouth above the tongue, or through the great opening towards the cavities of the nares, or even of dividing the aërial stream, so as to allow one part of it to fly out through one, and another through the other of these apertures; whence a variety is immediately induced upon the sound. There are naturally some words and syllables that are what is termed nasal and guttural, and that are not presented with their natural harmony and tone unless they are emitted simultaneously through both doors,—the mouth and the nares. When these words are pronounced, it becomes evident, that not only the velum palati, but also the very tongue, applied to the mouth or to itself, closes the passage against a quantity of the air that is about to escape.

(*e*) This seems to be the leading use of the ventricles of the larynx, namely, that in speech, when the sound is to be divided off into parts, they instantly close the passage for the air from the larynx into the palate; just as the palate has the office of intercepting the air, and preventing it from passing into the nares; and the tongue, from being poured forth through the aperture of the lips. For when the divisions, pauses or breathing times take place, then the air, being shut up also externally in the palate, is intruded and rushes through the fissures into these ventricles, and extends them. Thus the ventricles fill up the space that lies below the rima glottidis, and in a manner strip the escaping air of its wings. Without the detention of the breath or air, we can scarcely imagine how these ventricles or sinuses can swell up, for their orifices lie between the two superior and inferior [anteriori et posteriori] thyro-arytænoid ligaments; the thyro-arytænoid muscle also skirts the anterior border of the ventricles. In order, therefore, that they may be opened, and the air have an opportunity of entering them, it must necessarily come in from above, while the ligaments and

nal contrivance of nature, the tongue could never be taught to speak, nor could the mind, albeit it might command the mus-

internal muscular fibres of the thyroid are relaxed, and while the glottis is open: for at this time the ventricles, extended by the simple entrance of the air, seem to be able to stuff completely the inferior cheek of the glottis; and all the more closely if the thyroid muscle at the same moment, or even if the cartilage alone, in consequence of its retraction by the thyro-hyoid ligaments, acts or contracts. Inasmuch as this muscle covers their anterior borders, therefore, by its contraction, it causes the lower portion of the cavity of these ventricles to swell up, to the complete closing of the laryngeal orifice. This is the reason why animals that do not possess these ventricles, cannot divide their sounds, but draw forth the sound in one continuous thread; as is the case with oxen: while other animals that utter sounds discriminately or by intervals, as the neighing horse, do possess them. It should, however, be borne in mind, as before stated, that the continuity of the sound may also be intercepted by other natural instruments, for instance, by the velum palati and the tongue. But we must now subjoin from our Authors, a description of these ventricles, to enable the reader to form a judgment, in conformity we hope with what we have laid down, respecting the use of the same. "These two ligaments," says Morgagni, "leave between them on each side a nearly elliptical fissure, which is sometimes long enough to admit the end of the thumb, sometimes only to admit the tip of one of the fingers. . . . . These fissures are the orifices of two cavities; . . . . where they approach the base of the epiglottis the cavities become deeper, in consequence of the addition of appendages [ventriculorum appendices] of greater or smaller size. . . . The ventricles of the larynx are closed in acute, and expanded in grave tones. They are placed immediately within the circumference of the thyro-arytænoid muscles, and therefore also within that of the thyroid cartilage" (n. 356). "We observe," remarks Lancisi in his notes to Eustachius, (*Tabul. Anat.*, tab. xviii., fig. 25), "that the thyroid muscles are not intended for producing the motions of the thyroid cartilage, but for striking gently and at will upon the ventricles placed close underneath them. . . . The action of the thyroid muscles seems to me to be directed almost wholly to driving the sides of the ventricles forcibly inwards," &c. "Under these two ligamentary cords," says Winslow, "there are two others, which run likewise from behind forwards. The interval between the superior and inferior cords on each side forms a transverse fissure, which is the opening of a small membranous bag, the fundus of which is directed outwards, that is, towards the alæ of

cles of the larynx, commit anything to discourse. *For the larynx must be able to suspend sounds, to break them articulately, to introduce pauses between them, to take them up again, to continue and limit them, according to the articulations and breathing times in speech.* These powers belong to speech, the others belong to sound; for when the former are taken away, the only thing remaining is sound, with its proper discriminations or distinctions; that is to say, either acute or grave, weak or strong, canorous or vocal (*f*). All the other varieties of sound

the thyroid cartilage; these two sacculi are the ventricles mentioned by the ancients, and restored by Morgagni, who has given an excellent description of them" (n. 355). "On each side," says Verheyen, "between the two ligaments [connecting the thyroid cartilage and the epiglottis to the arytænoid cartilage], there lies a sinus of considerable size, about as long as the thumb is wide, and when expanded, of about the same breadth as length, but of greater depth. These sinuses are placed in the anterior part of the larynx, transversely under the epiglottis. They are of a semi-oval figure, as may be seen from the description of the ligaments that bound them, and constitute their two borders, superior and inferior. From their origin they pass on each side upwards and forwards, and about the middle of their height or depth, or perhaps a little farther on, they become suddenly contracted. They are so constructed that they can readily receive the air during expiration, but with difficulty during inspiration." (*Corp. Hum. Anat.*, tract. iii., cap. xi.) From a comparison of these authorities it may be seen, that the ventricles are filled with air, and swell, by the mere pause of breathing, that is to say, by the retention of the air, whatever may be the size of the aperture of the glottis. Thus they instantaneously stop the passage in the little throat of the larynx, whenever any little word is broken [off from the sound], or any stop, ever so small, interposed; as is happening every moment in the course of speech.

(*f*) In reality the universal essences of sound may be reduced to two; one that respects its quality, the other, its quantity: the variations of the former are properly termed modes or modifications, for while these vary, the essence is permanent. Acuteness is one extreme of quality; gravity, or if I may use the expression, grossness, is the other extreme; but the extremes of quantity are altitude, or the exaltation of the sound to the highest degree, and lowering, or the letting it down to the lowest, or until it is scarcely audible. To these I should also add a third kind,

are referable and convertible to these as general pivots, and result from the diversity of the membranes, cartilages, orifices, and origins:—I allude to such varieties as sweet, soft, gentle, voluble, clear, shrill, slender, puerile, feminine, and manly sounds; to unpleasant, rough, hard, theatrical, compressed, thin, languid, and dull sounds; also to the sounds of muttering, whispering, murmuring, hissing, creaking, stammering; and of neighing, bellowing, bleating, &c. (*g*).

namely, canorous sound or the sound of singing, and vocal sound, or that of words or speech; the differences between which appear to consist in the respective exaltation of the tremors. Canorous sound has in it a kind of compound tremor, made up as it were of subordinate lesser tremors; which produces the shrillness that is not observed in vocal sound. If we may make use of a comparison which is not, however, altogether applicable, there is a difference between the two like what there is between the leaping motions of the body, for the production of which the muscles of all the limbs require to be relaxed, so as to conspire together, and the ordinary step or walking gait. Thus by reason of its composition I have thought it right to add this third kind of sound: but all the other varieties result from these three, and are referable thereto: hardness, softness, shortening and continuation contribute nothing to the nature of sound, but only to presenting in different ways the varieties of the essentials.

(*g*) Human language is very inadequate to express the varieties and differences that obtain in sounds, and in fact in the other sensations, those, for instance, of taste and smell. We make use only of names derived from objects that excite similar feelings, and this in so indistinct a manner, that even the differences peculiar to one sense are applied to another, as sweetness, unpleasantness, smoothness, roughness and the like. Thus in discriminating the properties of sound, we are obliged to take from the common storehouse of language, words which the mind has privileged according to its affections. In each of these varieties there are again infinite other varieties,—of sweetness, clearness, sharpness, fineness, languidness,—which is the reason why the sound of one man's voice can never be altogether similar to that of another's. That sound is the most perfect which can be inflected into the greatest number of varieties; when from the harmonious conjunction of many sounds a pleasant concord is produced, which while it soothes the ear, soothes also the animal mind, and insinuates itself deeply and more deeply into the ideas of the rational mind, and keeps them intent upon

366. VI. *In order that the power of performing these offices may subsist in perpetual integrity in its organic parts and membranes, the larynx must renovate them in such manner and measure as use demands, with an unfailing spring of the most suitable humor.* For this end, a great number of glands are clustered together in the very beginning of the larynx, at the borders and circumference of the glottis, near the most moveable parts, and among the delicately tremulous and sonorous membranes; I mean, the arytænoid (*h*), epiglottidean (*i*), and other glands,

the successive series of things. There is also a variation according to age, and which is very remarkable in males about the time of puberty, when the cheeks begin to be covered with a tender down. The cause of this phenomenon lies too deep to admit of being explained in few words; as also particularly, that the puerile and virgin voice remains unchanged throughout life in those who have been castrated or spaded. Thus much is evident from the construction of the larynx, that at the time when the voice changes, the boundary of the aperture of the glottis must be naturally enlarged, and the manly gravity of tone thus produced. But the cause of its dilatation, must be sought in a change in the state of the nerve that supplies the larynx and trachea; also in the flux of the excrementitious humor, that being determined towards the chin and cheeks, exudes in the form of down, and assumes the appearance of a hairy growth. If we weigh all the circumstances, we shall find no likelier cause of the phenomenon, than a change of state in the restiform process of the cerebellum, which also supplies the generative organs, and an enlargement of that process about this vernal age. That this nerve produces these effects, and at this period directs the afflux of the pituitary and oily lymph of the sheath of the spinal marrow towards the region of the chin, I shall endeavor to prove in the proper place.

(*h*) The arytænoid glands, (which are excellently figured by Morgagni, *Advers. Anat.* i., tab. ii., fig. 1, 2, 6,) are described by Winslow as follows; "On the anterior surface of the arytænoid cartilages there is a small depression between the basis and the upper convex part: this depression is filled by a glandular body, which not only covers the anterior surface of each arytænoid, but is likewise extended forward from the basis, over the posterior extremity of the neighboring ligamentary cord. These glands . . . are covered by the membrane that lines the adjacent parts. They were discovered by Morgagni" (n. 355). Verheyen adds to these a new gland, situated, as he relates, in the

scattered here and there, at various intervals (*k*); not to mention the general glands, which, when commanded and solicited,

very commissure of the arytænoid cartilages: "I found another gland," says he, "in the posterior part, lying upon the upper border of the annular cartilage, within the two arytænoid cartilages, which in this spot were somewhat separated from each other." (*Corp. Hum. Anat.*, tract. iii., cap. xi.)

(*i*) The epiglottis also is covered with great numbers of glands, so that if we except its cartilaginous and membranous portions, the rest is almost entirely glandular; and for these glands, and the humor which they discharge, lacunæ, little sinuses and canals are hollowed out in the part, as is particularly well represented by Morgagni, *Op. cit.*, tab. ii., fig. 5. "The epiglottis," says Winslow, "is not only perforated by the regular holes already mentioned, but has likewise a great number of small irregular fissures and breaks of various kinds, which are so many different lacunæ, situated between its two membranes, and filled with little glands, the excretory orifices of which open principally upon the posterior surface of this cartilage" (n. 355). And Verheyen says, "On the gibbous portion or dorsum of the epiglottis, under the ligament, lies a very considerable gland, made up of a great number of other distinct glands; inferiorly it is thick and dense, and becomes gradually thinner towards the extremity of the epiglottis, so that at length the little glands are no longer united to each other. From this gland, or rather from these glands, several ducts pass through the cartilage itself to its internal or concave surface, the orifices of which ducts appear in this situation as so many large pin-holes, yet which are so firmly contracted, that very few of them will admit even the finest bristle. But where these ducts pass through the epiglottis, in some places there are as it were little channels or sinuses hollowed out in it, and glands placed in them, so that on the concave surface, by taking off the membranous integuments of the epiglottis, you will draw out not only excretory ducts, but a glandular substance along with them." (*Corp. Hum. Anat.*, tract. iii., cap. xi.)

(*k*) That a great number of other glands, thinly scattered, however, lie concealed under the membrane of the laryngeal tube, seems deducible from the circumstance, that new glands are being discovered every day, exactly in proportion to the skill of dissectors; and because under the larynx, in the trachea, glands of both kinds, aggregated and solitary, are discovered throughout. And moreover it is a part of nature's law, that not the smallest space shall be left without being occupied by some organ which contributes a share to the common good and advan-

seem also possibly to bend their streams of humors thither (*l*). But in order that the glands of the arytænoid cartilages and epiglottis, which glands are peculiar and proper to the larynx, may pour forth the precise quantity of lymph that is actually wanted and desired,—the quantity exactly proportioned to the exercise undergone in singing and speech,—they are placed in close connexion with those cartilaginous joints, moving fibres, and bands, which are perpetually vibrating, and living in action

tage. Verheyen says, "When the membrane that covers the interior surface of the larynx is removed, we find here and there, between the arytænoid glands and the epiglottis, certain little glands, which doubtless serve to secrete some similar humor" *(Op. cit.)*; and [according to the same author] small glands are also discovered at the bottom of the ventricles.

(*l*) Namely, the tonsils or amygdalæ, and the thyroid gland. The former are placed on both hands at the sides of the epiglottis, embraced by the columns of the velum palati, and in some measure connected also to the epiglottis. "There are," says Winslow, "two small lateral membranous ligaments belonging to it [the epiglottis], fixed near the little glandular bodies termed amygdalæ" (n. 355). They are seated consequently in the isthmus between the larynx and the pharynx; so that according to the determination of the action of the palate, they can spirt out their mucilage either to one or the other of these parts; consequently supply them both according to the requirement of use. But if we examine causes, it appears very likely, that when the tonsils are compressed they throw out their mucus into the pharynx; for they are furnished with a number of little cavities, and pierced with many minute holes. In like manner the thyroid gland, which must also be classed among the general glands, and of which we treated in Part I., in the Chapter on the Pharynx. Many persons question whether this gland transmits its liquid into the pharynx or not; but since it is extensively connected to the thyroid cartilage, and since it has been observed by some anatomists to communicate with the œsophagus by means of filaments, therefore it may possibly be serviceable to both. Nothing is of more frequent occurrence,—nothing is better established, than for one and the same corpuscule to serve many uses, exactly according to the nature of the want or requirement: a single little artery may distribute its blood to a thousand parts, and is bound to accommodate itself entirely to the use of each. Herein consists nature's perfection, that she can influence and inspire every particular with a

and modulation (*m*). And in order that they may distribute their streams equitably, according as they are required, to every point of the circumference of the tube, they are placed in the top or head thereof, and in the cone of the ægis of the epiglottis (*n*), and the lymph flows out by invitation, through conspicuous pores, into the cavity of the tube (*o*). Again, in order

common nature and spirit, that is, make one thing serve to satisfy the necessities of many. But respecting the way in which the thyroid gland ministers to the larynx, see below, n. 379 (*y*).

(*m*) As the arytænoid glands, which not only lie upon the arytænoid cartilages at the sides of the fissure of the glottis, but are also connected to the arytænoid ligaments, and to the thyro-arytænoid muscles; by which means, in every little vibration of those cartilages, and in every reciprocal expansion of the muscular fibre, these glands are struck by an external force, and roused to operate and discharge their fluid: likewise also by an internal force, for when the moving fibres are excited, their vessels and nerves are excited at the same time. The same holds good of the glands of the epiglottis; every time this cartilage is inflected to and fro, the membrane investing all the glands instigates them to pour out their humor, and to call forth a new supply thereof from the arteries: for the glands lie for the most part under the dorsal ligament, (according to the description given above in note (*i*), which ligament is being constantly moved and agitated by the tongue. Thus they pour forth their saliva in exact conformity to the locutory and modulatory motion; that is to say, in conformity to the action of the larynx.

(*n*) The whole of the humor discharged from the glands of the arytænoid cartilages and epiglottis, flows down over the entire circumference of the laryngeal tube; for the arytænoid glands occupy the posterior part of the rima glottidis; and the epiglottic glands derive all their oozings, through little channels, which form so many ready-made passages, to the anterior border of the glottis; from which afterwards the humor flows downwards over the entire circumference of the tube; and by the vibration of the cartilages within, and by the correspondent vibration of the membranes without, is scattered round about in all directions. The little canals channelled in the cartilaginous body of the epiglottis, are represented by Morgagni (*Advers. Anat.* i., tab. ii., fig. 5); other canals, nearly similar, only wider, are represented by the same author in the arytænoid cartilages. (*Ibid.*, fig. 6.)

(*o*) The holes which perforate the membrane covering the posterior

that this secretion by its over limpidity may not injure and lay bare the organ, its watery and volatile portion is carried off and eliminated in the form of vapor, by the air of the lungs during the alternate expirations (*p*); and in order that it may not be prejudicial by its over density, and blunt the organ, the dense portion is thrown off with coughing and expectoration, as a use-

surface of the epiglottis, are figured by Morgagni and Verheyen. "It [the epiglottis] is pierced," says Winslow, "by a great number of openings, which are hidden by the membrane that covers its two surfaces" (n. 355). The same is the case with the membrane that covers the larynx itself. "The membrane which invests the larynx," says Heister, "is very sensitive, and perforated with a great number of oscula or openings, which discharge a lubricating fluid" (n. 353). Thus the glands simply pour on their liquid, but the membrane itself dispenses it afterwards, and this, in proportion to the wants and uses of every fibre. For any fibre that is carried away too strongly into tremulous motion, and thence dried up too soon, has this liquid drawn to it, by a kind of attractive force, from the common reservoir; for in this state the fibre begins gradually to be blunted, torpid and quiescent, and thus to give forth more obtuse tremblings than the other fibres; wherefore a liquid and unguent is summoned thither from other parts, near and remote, that enjoy the greatest power of motion; and thus the humor is constantly equalized to all points of the membrane. This is the species of physical attraction to which I gave the name Invitation in Part I. of this work. Such seems to be the reason of the openings, and also of the discharge of humor from the glands inside the membranes; namely, that supplies may be brought thereby, not only to the external membrane, but also to the internal membrane or perichondrium.

(*p*) The air of expiration always appears humid and vapory, for it draws off the most limpid portion of the humor from the lungs, the trachea, the larynx, the palate and the nares, so as to leave the mucus behind. See above, n. 344. By this means precaution is taken, lest the glandular humor discharged through the orifices should be instantly dissipated, and provision is made, that the membrane of both the larynx and trachea may be continually covered with a certain mucilage; and thus the membrane is protected from being twitched or injured by the air, or by the occasionally foul halitus of the lungs, filled with ugly and misshapen particles; of which halitus we shall speak in the sequel, in our Chapters on the Trachea and the Lungs.

less phlegm, also by the same air: thus a humor ever fresh and ever exquisitely suitable, welling from its Parnassian spring, constantly waters and renovates this little machine,—as it were the vocal and eloquent instrument of the nine Muses. The necessity that exists for a due tempering of this mild salivary excretion, is indicated by the alteration which takes place in voice and singing under various circumstances; that is to say, by the membrane becoming rough and stridulous in consequence of being too dry; or shrill and clanging in consequence of being too hot or inflamed; or plashy and crepitous, from being too much moistened; or altogether silent, as in catarrh, in consequence of being inundated.

367. Besides these vital advantages and utilities, the larynx also affords remarkable and peculiar aid to its companion, the pharynx, in the office of eating; during which operation, it exchanges its own business for that of the pharynx, and this, indeed, with such amazing ingenuity, that by the very act wherewith it ministers to this work of the pharynx, it completely closes the glottis, and precludes the entrance thereinto of even the smallest crumb or drop, or of the air itself, as well as the exit of the latter. Thus the larynx completely abstains from its office when that of the pharynx is to be performed, disclaiming its own, and only claiming it for the pharynx. For the larynx, *Firstly*, inclines and inverts the little tongue of the epiglottis, and lays it down upon the glottis in such a manner as to form a bridge, whereby it unites the tongue to the pharynx, and affords a passage and uninterrupted path for the food (*q*). At the same

(*q*) Every tyro in anatomy is aware, that the epiglottis is bent completely back at the time of deglutition, so that the food can pass over it as a smooth bridge into the pharynx; also that at such time the respirations are held in. The causes and uses of this are also equally well known,—namely, that at the moment of deglutition, no part of the solids or fluids taken by the mouth, may rush into this neighboring and associate passage; which would give rise to sobbing, to sharp fits of coughing, of suffocation, or the like. But that such innumerable powers and forces concur to this single effect; and that the pharynx also is ministered to by the same act and art,—these I think have not hitherto been so well known as the former circumstances.

time it closes the door, and prevents itself from taking any portion of the provisions of the pharynx; and even vacates its office, lest it should draw in the slightest breath. This is brought about by the help of the ligaments, the base of the tongue being rolled back into the hollow, and the os-hyoides laid down flat (*r*): also by the trusion exercised by the food, to which the cartilage contributes in some slight degree by means of its muscle, the hyo-epiglottideus. *Secondly*, the larynx secures the glottis itself; for the membrane of the palate inclines inwards to its orifice, and passes deep under the tongue; thus it gives the pharynx the power of swallowing, and deprives itself of the power of respiring. The orifice of the glottis is secured, and stuffed by the membrane of the palate, anteriorly, by means of the depression of the epiglottis (*s*); posteriorly, by the palate, the velum palati, and the muscles of the velum; also by the pharynx itself, its expansion into a swallow, and the folding of the isthmus brought about by this expansion (*t*). The whole

(*r*) See above, n. 362 (*a*). The epiglottis is so placed and articulated upon the fissure and hollow of the thyroid cartilage, that it is capable of turning and accommodating itself to the smallest rolling of the base of the tongue: for there is an almost globular appendage, implanted in a certain little cavity at the top of the crest of the thyroid helmet, in the middle of the projecting part; by means of which, the epiglottis may be inflected backwards and forwards without the least change of place in the thyroid cartilage, and this may even occur in some degree by means of the hyo-epiglottideus muscle. Respecting this globular appendage, see Verheyen, *Corp. Hum. Anat.*, tract. iii., cap. xi.; [also tab. xxii., fig. 4.]

(*s*) We before pointed out that the epiglottis is surrounded by a production of the membrane of the palate, and constitutes the anterior border of the glottis: consequently when the epiglottis is inflected, this membrane yields inwards, and is slackened about the glottis, and therefore is also relaxed all round the same fissure; for the membrane is continued from the epiglottis round the whole area of the orifice and round the cavity of the larynx. See above, n. 361 (*s*).

(*t*) That there is a certain little interstice which I term the isthmus between the pharynx and the larynx, and that the membrane of the palate, and the pituitary membrane of the nares, are continued into both the pharynx and the larynx, and thus cover and construct this

of the larynx with the rima glottidis is drawn up close under the root of the tongue, namely, by the tongue itself, the ligaments, and the hyo-thyroid muscles (*u*), and is returned to its place by the sterno-thyroid muscle (*x*). *Thirdly* and lastly, the larynx draws together the arytænoid cartilages, locking and shutting the glottis into a mere fissure, and unlocking the sphincter of the pharynx; thus it altogether gives up its own life; these results are brought about by means of the thyro-pharyngeal and crico-pharyngeal muscles (*y*), aided and assisted

isthmical interstice,—this is plain from the situation and connexion of all the parts. Therefore when the food is rolled into the pharynx, and the pharynx, by these means, is expanded for swallowing it, the necessary consequence is, that this membranous interstice is rolled in upon the larynx, the palate itself, with the velum and its muscles, and also the tongue, concurring, according to the observations of Boerhaave, *Inst. Med.*, n. 70, 71.

(*u*) Respecting the hyo-thyroid muscle see above, n. 364 (*u*).

(*x*) The sterno-hyoid muscle is the close companion of the sterno-thyroid all the way from the sternum or clavicle along the trachea and the thyroid cartilage, whence it passes to the os-hyoides; and the sterno-thyroid is covered during its course by the sterno-hyoid, which shews that the two are intended and made for the performance of common offices. This is also very evident from the operation of eating or swallowing; for when the os-hyoides is carried backwards, and the tongue also rolled back and raised up, then the sterno-hyoid muscle is brought into action.

(*y*) Among the muscles of the pharynx is its single constrictor, termed œsophagæus or sphincter gulæ. "Valsalva," says Heister, "observing the numerous origins of this muscle, divided it into three pairs: and Douglas, Cant, and Santorinus, into still more, which from their origin and termination, they name hyo-pharyngæus, thyro-pharyngæus, crico-pharyngæus, &c." (n. 74). "The thyro-pharyngæi," says Winslow, "are very broad, and each muscle is inserted along the outside of the ala of the thyroid cartilage. . . . They have appeared to me to be distinguished into two muscles, a superior and an inferior. . . . The crico-pharyngæi are inserted each in the lower part of the side of the cricoid cartilage. They are nothing more than a continuation of the thyro-pharyngæi . . . . but as they run backward they descend a little. . . . The lowest of these muscular fibres make a complete circle, from one side of the base of the cricoid cartilage to the other side; this

by the proper constrictors of the larynx. Such is the successive series of efficient causes; and from this successive series there constantly arises a simultaneous series and coöperation of all things, which is termed the effect (*z*).

circle is the beginning of the œsophagus." *(Exp. Anat., Tr. de la Teste*, n. 482, 483, 484.) If we contemplate and examine the larynx in connexion with its cartilages, muscles and ligaments, directing our attention to all the parts at once, we shall clearly perceive that the pharynx, in the process of deglutition, when its sphincter is unlocked and expanded, in order to open a passage for the food to descend, endeavors to move off the larynx in a general manner, but that when the muscles are aiming at a contrary effect, the pharynx draws close to it the two primary cartilages of the larynx, and thus the larynx itself at the same time. The effect of this adduction and unition of the two cartilages, is, that the arytænoid cartilages, which we term the little lips of the mouth of the glottis, are pushed in towards the fissure; for when the thyroid and cricoid cartilages are drawn back, they push inwards the arytænoid cartilages superiorly; so that very little space is left between the border constituted by the arytænoids, and the anterior border formed by the epiglottis; especially when the membrane of the anterior border is relaxed by the introflexion of the epiglottis. If we lay our finger on the thyroid cartilage during deglutition, we feel that the whole larynx is raised at the instant, and drawn up close under the tongue, so as to escape from beneath the finger. Thus the thyroid cartilage is at this time forcibly pushed and drawn towards the os-hyoides; so consequently are also the arytænoid cartilages, by means of the thyro-arytænoid ligaments and muscles: whence the rima glottidis is closed.

(*z*) We have clear evidence of the immense numbers of causes that enter a single effect, and vary it according to the state of operations, not only from the coöperation of the larynx and pharynx, and of the palate and tongue, and their muscles, but in fact from all the actions of the body. A single action, be it ever so little compounded, is made up of an infinite number of forces, all of which at first generally succeed each other in a continuous series, but ultimately unite into a kind of simultaneous series. For everything simultaneous arises from things successive: hence effects arise according to the succession of causes; and quality is predicated of these effects, according to the various influx of the causes; this quality being, therefore, of infinite variety. This is exemplified in the larynx, in one way when it only concurs with the pha-

rynx in eating and swallowing; differently again when it exercises its own powers of modifying sounds and articulating words; also when it ministers to the lungs in respiration; differently again when it yawns, sneezes, sighs, coughs, spits or expectorates, sobs, hisses, cries, bellows, sings to instruments, &c.

CHAPTER III.

THE TRACHEA.

368. Heister. "The aspera arteria, trachea or windpipe, is a cartilaginous canal extended from the fauces to the lungs. It is situated in the middle and anterior part of the neck; connected with the fauces, the lungs, and the œsophagus; and divided into two parts, 1. the larynx; and 2. the aspera arteria, or trachea, strictly and properly so called. . . . The trachea is the remainder of the cartilaginous canal before described. [See *Animal Kingdom,* n. 353.] It is slightly conical in figure, and extended from the larynx to the bronchia. The beginning of the trachea is round, and so large that it readily admits the finger; the end is a little narrower. It enters the thorax under the sternum, and there, before it joins the lungs, divides into two branches, a right and left, termed the bronchia; which afterwards subdivide into the finest twigs, are distributed through the lungs in all directions, and ultimately terminate in the pulmonary vesicles. It consists of from sixteen to twenty cartilaginous rings, and of four coats. The annuli or rings are imperfect: for the whole trachea on its posterior part, and the beginning of the bronchia, are membranous; partly, that they may not impede deglutition; partly, that these canals may be capable of being contracted and dilated, to assist in the variation of the voice, and in the expulsion of excretions. Of the four coats, the exterior is membranous; the second, glandular; the third, muscular, the fibres of which are transverse, and unite together the two extremities of each ring, and serve to contract them; the fourth or internal coat is tendinous and robust, and by its longitudinal fibres may shorten the trachea and bronchia: it has in it a great number of oscula or openings coming from the glands of the second coat. The arteries of the trachea are from the external carotids; the veins from the jugulars; its nerves are from the recurrent nerves and cervical plexus. . . . Certain

remarkable glands lie upon the outside of the trachea, and appear to serve for moistening it; these are the thyroid and the bronchial glands. The thyroid is large, in shape very much resembling a new moon: it is connected by its middle part to the superior rings of the trachea, but by its cornua which run directly upwards on both sides, to the larynx, and the œsophagus. The bronchial glands are of various sizes, large and small. They are of a blackish color, and are connected to the lower part of the trachea, to the divisions of the bronchia, and to the œsophagus: their use is doubtful. *(Comp. Anat.*, n. 259.) During the year 1723, in one male subject I found many black glands of this kind, adhering to the whole posterior surface of the trachea, near the œsophagus, of a size between a grain of wheat and a kidney bean, and some adhering loosely to the anterior part of the trachea also." *(Ibid.*, n. 388.) Respecting the thyroid and bronchial glands, see Part I. of this work, n. 73.

369. WINSLOW. "The bronchia are branches of a large canal, partly cartilaginous and partly membranous, called trachea, or aspera arteria. It is situated anteriorly in the lower part of the neck, from whence it runs down into the thorax, between the two pleuræ, through the upper space left between the duplicature of the mediastinum, behind the thymus gland. Having reached the curvature or arch of the aorta, it divides into two lateral parts termed bronchia, one to the right, the other to the left, which enter their respective lungs. The bronchial tube of the right side is shorter than that of the left. The trachea is made up of a number of segments of circles, or cartilaginous hoops, placed one upon another, and disposed in such a manner as to form a canal open on the back part: but the defect in the cartilaginous portion is compensated by a soft glandular membrane, which completes the circumference of the canal. Each circle is about the twelfth of an inch in breadth, and about a quarter of that space in thickness. Their extremities are round, and they are situated horizontally one above another, small interstices being left between them, and the lower edge of each segment being in relation with the upper edge of the segment next below it. They are all connected by a very strong elastic membranous ligament fixed to their edges. I have observed the first three circles united into one piece, bent alternately in two different places in the direction of its breadth [largeur]. The canal of the trachea is lined on the inside by a particular membrane, which appears to be partly fleshy or muscular, and partly ligamentary, perforated by a great number of small holes more or less imperceptible, through which a mucilaginous fluid continually passes, to defend the inner surface of the trachea against the acrimony of the air which we breathe. This fluid

comes from small glandular bodies dispersed through the substance of the membrane, but especially from glands somewhat larger than the former, which lie on the external or posterior surface of that strong membrane which completes the canal, and supplies the defect in the cartilaginous circles. Almost the same structure is observable in the ramifications of the trachea [the bronchia] to their extremities. *(Exp. Anat., Tr. de la Poitrine,* n. 127—133.) Coats:—The trachea has several coats: the outermost or common covering surrounds that part of the trachea which lies in the thorax, but out of the thorax this first coat is derived from the aponeurotic expansions of the muscles of the neck; and it is between this and the following coat that the glands already mentioned are situated. The second or proper coat is cellular, and is a continuation of the cellular covering of the lungs; and the pellicles thereof nearest the cartilaginous segments serve them for an external perichondrium. The third membrane lies on the inside, adhering closely to the same cartilages, and serving them as an internal perichondrium. The fourth membrane is that which supplies the defect in the cartilaginous canal of the trachea. It consists chiefly of two planes, partly muscular and partly tendinous, the external or posterior of which is made up of longitudinal fibres; and the internal or anterior, of transverse fibres. This membrane is perforated by the little ducts of the above-mentioned glandular granules; which discharge a fluid when pressed, and being examined by the microscope appear vesicular or follicular, much like those of the stomach. The ligaments between the cartilaginous circles are very strong and elastic, and each of them is confined to two cartilages without communicating with any of the rest; they are fixed to the edges of the cartilages, much in the same manner as the intercostal muscles are inserted in the ribs. *(Ibid.,* n. 144—147.) At the angle of the first ramification of the trachea we find on both the anterior and posterior parts certain soft roundish glandular bodies, of a bluish or blackish color, and of a structure very like that of the thymus and thyroid glands. There are other glands of the same kind at the origin of each ramification of the bronchia, but they decrease proportionably in number and size. These glands are connected immediately to the bronchia, and covered by the interlobular substance; and they seem to communicate by small openings with the cavity of the bronchia. *(Ibid.,* n. 143.) Arteries:—The carotid arteries are two in number; one called the right carotid, the other, the left: they arise near each other from the curvature or arch of the aorta; the left immediately, the right most commonly from the trunk of the right subclavian. They run up each side of the trachea, between it and the internal jugular vein, as high as the larynx, without having any ramifi-

cations. . . . They then divide into two large branches or particular carotids, one named external, the other internal. The external carotid is anterior, the internal posterior: the external is both more inward and nearer to the larynx than the internal. The external is the larger of the two; it runs insensibly outward, between the external angle of the lower jaw and the parotid gland. In this course it gives off several branches, which may be divided into anterior or internal, and posterior or external. The first anterior or internal branch is given off from the very origin of this carotid on the inside, and immediately taking a little turn, and sending branches to the neighboring jugular glands, to the fat and skin, it runs transversely, and is distributed to the thyroid gland, and to the muscles and other parts of the larynx: for which reason I name it, laryngeal or superior guttural artery. It likewise sends some branches to the pharynx and to the muscles of the os-hyoides. *(Ibid., Tr. des Arteres,* n. 46—52.) Veins:—The external anterior jugular vein is often a branch of the internal jugular vein, and sometimes arises from the reciprocal communications of the two jugulars. . . . Posteriorly it gives off a large branch on the side of the upper part of the larynx, which communicates with the internal jugular. . . . Anteriorly it sends several branches to the muscles of the larynx, sterno-hyoidei, thyro-hyoidei, and the integuments; and below the larynx it sends communicating branches to the external anterior jugular vein of the other side. *(Ibid., Tr. des Veines,* n. 72—75.) The internal jugular vein is the largest vein of all those that go to the head. The first branches which it gives off are small, and go to the thyroid glands: at about two finger-breadths higher up it gives off a middling-sized branch, which runs laterally towards the larynx, and may be named the guttural vein. This vein divides chiefly into three branches; the lowest of which goes to the thyroid gland and neighboring muscles; the middle branch, to the larynx, thyroid muscles, &c.; the third ascends to the great communication already mentioned between the two jugular veins. *(Ibid.,* n. 102—105.) Nerves:—The third branch [of the eighth pair] passes between the cornu of the os-hyoides and the ala of the thyroid cartilage, and running in between that cartilage and the cricoid, it communicates with the extremities of the recurrent nerve. Afterwards the large trunk runs down in front of the first ganglion of the great sympathetic or intercostal nerve, along the anterior vertebral muscles of the neck, by the side of the carotid artery, and behind the internal jugular vein; being accompanied closely by the intercostal nerve, as far as the last vertebra of the neck. Through all this course this trunk is invested by a kind of cellular, filamentary, or membranous sheath, common to it with the internal carotid artery, the internal jugular vein, and the great

sympathetic nerve. In its passage it gives small branches to the neighboring parts,—to the pharynx, œsophagus, and to the carotid artery and jugular vein. One of these small branches in its course downwards, joins a small branch of the second cervical pair, and is distributed to the thyroid gland. The trunk having reached as low as the larynx and thyroid gland, sends out a branch, which running down in front of the internal carotid artery, joins a filament from the second ganglion of the intercostal nerve, with which it passes to the pulmonary plexus. . . . As the right trunk passes before the subclavian artery, it gives off a considerable branch, which bends backward under the artery, and mounts up the side of the trachea, to which and to the œsophagus it gives filaments all the way to the posterior part of the larynx: this branch is the recurrent nerve. This recurrent nerve having reached the larynx gives branches to its muscles, to the pharynx and thyroid gland. Then it runs in behind the cornua of the thyroid cartilage; where it joins the extremity of the third branch of the trunk of this eighth pair, communicating with it in the manner already described. When the trunk of the right side has given off the recurrent of the same side, it runs down the side of the trachea and behind the root of the right lung, in order to connect itself to the œsophagus." &c. (*Ibid., Tr. des Nerfs*, n. 117—124.)

370. MORGAGNI. "The semiannular cartilages exist not only in the part of the trachea within the thorax, but also in the two branches of the bronchia into which the trachea first divides. . . . In dissections of the trachea it is not uncommon to find some of its cartilages grown together at the extremities, and some much broader than others. These varieties are more frequent, if there be any difference, in the first cartilage; which not seldom is broader in itself, not seldom is exceedingly broad, in consequence of being united to one, or even to two of the other cartilages. Besides, it is unlike the others in length, and particularly in shape; in fact, I have often found it the shortest [in diameter] of all the cartilages. . . . All along the back of the trachea, and of the first branches of the bronchia, where the cartilages are deficient, when the exterior coat is taken off, a great number of glands come immediately into view. These glands are roundish, oval, and compressed, and of various sizes, but for the most part larger than millet seeds. They transmit their little ducts through the muscular [carneas] fibres lying under them, to the inside of the trachea. . . . On the internal coat we find certain strong fibres [lacerti] composed of white glistening fibrillæ. These commence some finger-breadths above the division of the trachea, and are disposed upon it lengthwise, being situated in the before-mentioned interstice; and when they reach the second division of the bronchia,

they then for the first time overspread the whole surface thereof all the way to their extremities." (*Advers. Anat.* i., n. 24, 25 ; and tab. i. ii.)

371. BOERHAAVE. "The trachea,—consisting of semicircular, cartilaginous segments, completed behind, where the cartilage is deficient, by a dense membrane, and connected together by strong muscular bands,—allows a free ingress and egress to the air, the pipe being always open, along the smooth and slippery sides of the membrane; so that this part may be expanded circularly, and yield to the œsophagus during deglutition; may follow the posture or bend of the neck; and may readily be either elongated or shortened. The whole of the membrane that makes up the back of the trachea, where the rings are deficient, is beset with glands that prepare an unctuous humor, and discharge it by ducts perforating the fibrous coat, into the cavity of the trachea: this humor anoints and lubricates the pipe.—The trachea, bifurcating about the fourth dorsal vertebra, is still composed of cartilages that are imperfect rings behind, and of the glandular membrane before mentioned, and soon afterwards divides into innumerable branches on each side; the branches having nearly the same structure as the trachea itself, only that their annular segments are more complete, and the oily lacunæ are there placed on the inside among the strong fibres. These branches lie at acute angles to each other, and become gradually smaller and thinner, till at their extremities they lay aside their cartilaginous nature, and become membranous; and the force of the air extending their pliable parietes, converts them into small flexible sacs, growing upon all the extreme points of every branch; which sacs form vesicles," &c. (*Inst. Med.*, n. 195, 196.)

ANALYSIS.

372. As the trachea is a windpipe intermediate between the larynx and the lungs, so when rationally examined by anatomy, it instructs us farther upon those points which we have still to learn respecting the larynx; and it also furnishes us with the rudiments or necessary preliminaries of those points which are to be unfolded in the sequel respecting the lungs. Consequently the trachea serves us as a supplement and epilogue to the harmonic science of the sounds of the larynx, and as an introduction and prologue to the pneumonic science of the respiration of the lungs. For whatever is really pulmonic is a property of the great trachea, just as whatever is arterial is a property of the great artery. The lungs, considered as to their office, are only the continuous ramification of the trachea, in the same manner as the arteries are the continuous ramification of the aorta. Thus we contemplate all the parts in the lungs, (that is to say, the lungs themselves in their parts,) in the trachea, as the smallest effigy in the largest (*a*).

(*a*) There is no other difference between the trachea and the lungs, than such as there is between the general and the parts, or between continuous and discriminated quantities. The principal pulmonic substance,—that substance by virtue of which the predicate, pneumonic, belongs to the lungs,—consists exclusively of the ramifications of the trachea; for the trachea divides into bronchia, these into bronchiola, or lesser bronchia, that is, constantly into branches, and so to the ultimate ends, which are the vesicles. Consequently from the trachea we may learn the nature of its branches, in the same manner as from the aorta we may learn the nature of the little arteries, down to the most minute capillaries. Indeed, according to anatomical experience,

373. The proper uses of the trachea are the common uses of the lungs and of the larynx. The trachea is of use, I. To afford a channel for the atmosphere, and for the breath of the lungs, to pass and repass; and to accommodate itself to all the numerous and diversified modes of action of the lungs, both in inspiration and in expiration. To examine and correct the air that is about to pass into the lungs, and prevent anything hurtful from entering; and to impregnate with vapors the air that is passing out: thus to entangle effete exhalations, and prevent the contiguous parts from being injured thereby. Likewise in general to clear the lungs from viscid phlegm by expectoration. II. To serve as a pillar and support to the larynx; and to adapt itself exactly to the beck and nod of the latter, and to its tremulous vibrations. To dispose the parietes of its canal, so that the air may impinge upon them; and to stretch or tighten its membrane, so that when the air impinges the mem-

whithersoever the assistance of the microscope enables us to penetrate, we find a not dissimilar image in the very branches of the bronchia, to that which exists in the trachea; so that the matter of size, and the accidents of size, are all that play before our senses, presenting the appearance of variety; that is to say, in the lesser parts, there is respectively a simplicity, fineness and delicacy in all those things that in the larger parts are compounded, complicated and hardened; for instance, instead of simple and perfectly thin and elastic membranes, we have membranes composed of various layers, membranes muscular, glandular and tendinous, or even furnished and strengthened with cartilaginous rings. With the exception of these degrees of simplicity in structure, and consequently in operations, there is very little difference indeed between the trachea and the bronchia, and the little branches of the latter. "Almost the same structure," says Winslow, "is observable in the ramifications of the trachea [the bronchia] to their extremities. . . . At the angle of the first ramification of the trachea we find . . . certain glandular bodies. . . . There are other glands of the same kind at the origin of each ramification of the bronchia, but they decrease proportionably in number and size" (n. 369). "The trachea," says Boerhaave, "bifurcating about the fourth dorsal vertebra . . . soon afterwards divides into innumerable branches on each side; the branches having nearly the same structure as the trachea itself," &c. (n. 371).

brane may tremble; and thus to excite the rudimentary sound, for the larynx afterwards to form into singing or speech, that is, to modify: also to moisten the larynx continually with a vapory dew. III. To aid and assist its neighbor, the œsophagus, in the office of deglutition. Also to divide and share the salivary humor proceeding from its springs, in just proportion between itself and the œsophagus, according to the necessities of each. IV. To pour the alternate respiratory motions of the lungs into the neighboring parts, and thereby into the remote and ultimate parts; namely, into the œsophagus, and thereby into the stomach, and so into the viscera of the abdomen: also into the great sympathetic nerves,—the intercostal and the par vagum: and into the ascending carotid artery and the descending jugular vein; and thereby into the universal system: thus to renovate the motive life of the body. V. To insinuate into the neighboring parts, and thereby into all other parts, high and low, its own sonorous tremblings, as well as those of the larynx: thus to excite the arterial blood mounting to the head and brain, and the venous blood returning from the head and brain, together with the ear, the companion in office of the trachea, and to exhilarate and animate them by a general modification: thus to renovate the sensual life of the body. VI. To represent in itself, as in an image, how every member of this body or kingdom lives for all the other members, and not for itself alone. We shall now consider each of these uses separately.

374. I. *The trachea affords a channel for the atmosphere, and for the breath of the lungs, to pass and repass, and accommodates itself to all the numerous and diversified modes of action of the lungs, both in inspiration and in expiration.* The great diversity of these modes of action will be clearly evident to our first sense (*b*), if we only enumerate the varieties of the common states of the respiratory motion; for respiration may be either ordinary or extraordinary, or asthmatic and morbid, or different according to the different disposition as well as action of the ribs, the vertebræ, the sternum, the neck, the head, the brain, the medulla oblongata and spinalis, the nerves and the muscles:

(*b*) Namely, to the first internal sense, which comes next to ocular vision, and to which imagination is referable.

respiration is one thing in women who wear tight stays, another thing in pregnant women; different again in infants, boys, adults, and old persons, respectively: respiration may be either pectoral, attended with rising of the chest; or dorsal, with adduction and extension of the vertebral column; or subthoracic and abdominal: it is different again in other states, for instance, while we are sleeping and snoring, from what it is while we are awake, standing upon the feet, bending forwards, backwards, or sideways, or lying upon the back, or upon the breast: it varies also respectively while we are laboring, shouting, speaking, singing, eating, crying, laughing, coughing, sighing, yawning, sneezing, running, panting, riding, fighting with the whole chest, arms, or feet, sitting, ascending, descending, expelling the fæces, passing the urine; also during parturition, copulation, stretching the first thing in the morning: it changes with all the diseases of the body, with all the emotions of the animal mind, as in joy, anxiety, anger, fury, fear, intrepidity, attention, eagerness, &c. To all these modes and their particulars, this single breathing-pipe is accommodated, by means of diversiform flexures, elongations, shortenings, expansions and contractions,—oblique, curved and straight,—without causing any interruption of the functions of the larynx, the pharynx, the œsophagus, the lungs, or the adjoining parts. Indeed there is no other simply tubular organ in the body, so far as we know, that sustains so constantly so great a number and variety of inordinate and inconstant motions (*c*). For this

(*c*) In no other part do so many extraordinary motions meet together as in the trachea; that is to say, there are the respiratory motions of the lungs, the infinite variety of which is very evident from the enumeration given above of the general varieties of respiration: also all the motions, modes, and articulations of the sounds of singing, and of the words of speech, to the whole of which the trachea has to adapt itself. Not a syllable issues from the mouth, but the trachea must concur to it with a general assent, by some inflexion, expansion, or contraction of its own. The trachea has likewise to adapt itself to every motion of the œsophagus, the pharynx, the palate, and the tongue: again, to every bend of the head, the neck, and the cervical vertebræ: in a word, to all the actions of the muscles, not only of this region, but of the thorax, and sometimes also of the abdomen.

reason its common coat or robe is an aponeurotic expansion of numerous muscles, and as it were a circular foot-stay and common tendon of their extremities (*d*): not continuous however with the common coat of the lungs, but a member by itself, and therefore the ready subject of infinite motions besides the pulmonary and laryngeal motions. For the same reason its cartilaginous rings do not encompass it completely, being only segments of circles, or imperfect girdles; but a strong and elastic membrane, furnished with fibres at once active and yielding, that is, compliant to every impression, completes the circuit posteriorly; whereby the tube is rendered capable both of extension and dilatation, and of varying the dimensions of its cone in all sorts of different ways (*e*). This semiannular struc-

(*d*) That the trachea is born and made for the varieties of all these numerous and remarkable motions, is perfectly evident from its whole structure; in particular, from its common coat, which is a kind of termination of certain muscles, more especially of the sterno-hyoidei and thyro-hyoidei; so that every action which results from the muscles of the chest to the clavicle and sternum, and by these means to the muscles before mentioned, ultimately centres in the trachea. Respecting this coat, Winslow says, "The outermost or common covering surrounds that part of the trachea which lies in the thorax, but out of the thorax this first coat is derived from the aponeurotic expansions of the muscles of the neck" (n. 369).

(*e*) It is well known that the cartilages of the trachea, (which are from sixteen to twenty in number, and united to each other by tendinous membranes,) do not form complete circles, but terminate after a partial gyre, and that the defect behind is supplied by means of a strong muscular and fibrous membrane. "The trachea," says Winslow, "is made up of a number of segments of circles, or cartilaginous hoops, placed one upon another, and disposed in such a manner as to form a canal open on the back part: but the defect in the cartilaginous portion is compensated by a soft glandular membrane, which completes the circumference of the canal. Each circle is about the twelfth of an inch in breadth, and about a quarter of that space in thickness. Their extremities are round, and they are situated horizontally one above another, small interstices being left between them, and the lower edge of each segment being in relation with the upper edge of the segment next below it" (n. 369). From the above mechanism, without any deep investigation or intuition into the hidden powers of mechanical

ture bears a certain resemblance and analogy to the costal structure in the chest and abdomen; namely, in this respect, that it makes the anterior part capable of being elevated, while the posterior part remains at rest, and that in this case the space is at the same time enlarged by the elevation (*f*); by which

science, it may be seen immediately that the tracheal tube admits of being expanded and contracted,—of being enlarged and diminished in capacity,—in a variety of ways; which could not possibly have been the case, had the circles been perfect, and described an entire circumference: but as it is, the extremities of the segments terminating in the above membrane, may be variously separated or drawn together, thus causing corresponding varieties in the spaces comprised between them. Any cartilage, so far as it is elastic, may be bent from a curve into a straight line, or from a straight line into a curve, but not so if it completes a circle; as neither can elastic threads, whether they consist of tendon, wood, steel, or any other material, provided they are joined at the extremities, so as to form an entire circle. Cartilages of this kind, arched, but not absolutely bent together, admit of being drawn out variously, upwards and downwards, even with respect to their extremities, and in this way are capable of assuming different species of forms; as happens when the membrane supplying the defect in the rings,—the posterior membrane,—is in a state of rest, and the rings are moving up and down the meanwhile. Thus this membrane seems to be the regulator of the calibre of the tube, and the cartilaginous portion to be the regulator of its height. "The fourth membrane," says Winslow, "is that which supplies the defect in the cartilaginous canal of the trachea. It consists chiefly of two planes, partly muscular and partly tendinous, the external or posterior of which is made up of longitudinal fibres; and the internal or anterior, of transverse fibres" (n. 369).

(*f*) If we grant that the posterior or membranous portion of the tracheal tube is at rest, and is not carried upwards and downwards to the same degree as the anterior or cartilaginous portion, then it will follow, that the calibre of the tube is rendered smaller by the depression of the anterior portion, that is, of the rings; for when the circles are depressed anteriorly, the interposing substance is narrowed; of which circumstance we may have ocular demonstration, by connecting a number of similar circles into a tube, and depressing one side of the tube. We also know that there is the same mechanical adaptation in the ribs, and in the capacity of the chest as affected by the ribs; for when their

arrangement, the extension involves the cause of the dilatation, and the depression involves the cause of the constriction,—precisely as in the thorax; so that on account of this analogy, the cartilaginous circles may perhaps be aptly termed the cervical or tracheal ribs. By bearing in mind the foregoing circumstances, we may infer what the action is superiorly, or under the larynx, where these little ribs form still more imperfect circles, and approach nearer to each other; what it is in the middle of the tube; and what it is inferiorly, in the neighborhood of the bronchia, where the rings are more complete (*g*).

375. *The trachea examines and corrects the air that is about to pass into the lungs, and prevents anything hurtful from entering;* namely, by means of the pituitary humor which the glands pour forth, and with which the parietes of both the trachea and the bronchia are besmeared and moistened, catching and ensnaring any particles that either accompany or are indigenous to the air

fulcrum or common centre of motion,—the vertebral column,—is at rest, then the intervening space is enlarged or diminished by the depression or elevation of the ribs.

(*g*) High up, near the larynx, these annular segments are more imperfect, because shorter; but lower down, about the bronchia, they are more perfect, more entire, and almost circular in form. Respecting the uppermost cartilage, Morgagni says, "The semiannular cartilages exist not only in the part of the trachea within the thorax, but also in the two branches of the bronchia into which the trachea first divides.... In dissections of the trachea it is not uncommon to find some of its cartilages grown together at the extremities, and some much broader than others. These varieties are more frequent, if there be any difference, in the first cartilage; which not seldom is broader in itself, not seldom is exceedingly broad, in consequence of being united to one, or even to two of the other cartilages.... I have often found it the shortest [in diameter] of all the cartilages" (n. 370). "The branches [or bronchia]," says Boerhaave, "have nearly the same structure as the trachea itself, only that their annular segments are more complete" (n. 371). It is evident from these statements, that the bronchia admit of less expansion in breadth than the trachea, but of greater extension in length. But the contrary is the case in the upper part of the trachea, where a compound and stronger action occurs, for the sake of sustaining the larynx.

which we breathe; that is to say, any heavy, inert, unshapely, pointed, fetid, or putrid particles, that would injure the secret and exquisitely delicate vesicles of the lungs. To avert and put aside the mischievous and dangerous consequences which might otherwise be occasioned, a great number of common or general glands are collected in the beginning of the tube, and inserted therein at its angles or bifurcations, as well as in all the intervening spaces (*h*): a great number of particular and solitary glands are also scattered over both its surfaces, interposed between the membranes subject to perpetual agitation, and furnished with excretory ducts determined to the cavity, and with

(*h*) The common glands are the thyroid and the tracheal glands, which [latter] being placed between the membranes of the trachea, cannot but eructate a large quantity of humor every time the sterno-thyroid, sterno-hyoid, and hyo-thyroid muscles act; for the trachea is covered by the fibres of those muscles. The same must be the case with the bronchial glands, every time the same muscles operate, and particularly the sterno-hyoid; for these muscles, in their ascent, adhere to the trachea, and give it its tendinous coat: close under this membrane lie the glands; as likewise in all the bifurcations of the bronchia. "There are other glands of the same kind," says Winslow, "at the origin of each ramification of the bronchia, but they decrease proportionably in number and size" (n. 369). Inasmuch as they are placed between the membranes, and in a kind of cellular substance, therefore a secretion must necessarily be forced from them during each alternation of expansion and constriction, and carried round the whole circumference of the tube. For according to Winslow, "These glands are connected immediately to the bronchia, and covered by the interlobular substance;" and again, "The canal of the trachea is lined on the inside by a particular membrane, . . . perforated by a great number of small holes more or less imperceptible" *(Ibid.)* I say nothing of the little mouths of the ducts running from the glands to the cavity. Thus in the moistening of the trachea, as in all nature's other operations, there is a general and there is a particular; namely, general and particular glandular springs: and in this manner every point of the trachea, like every point of the larynx, (as mentioned in the last chapter,) is supplied according to its degree of action, and according to the want and nature of the membrane, and thereby is preserved in integrity, and in the state proper for its motions and functions.

little foramina also opening thither (*i*): thus the sides of the tube are limed throughout, and covered with an ensnaring humor, which steals away from the air the injurious particles. For the same reason the trachea, the bronchia and their branches decrease constantly in diameter, forming an uninterrupted cone all the way to the vesicles; new tracheolæ or bronchial joints come off continually at oblique angles from the joints preceding them (*k*), and ultimately contract in the closest manner into the most perfect aërial filters. Thus the air, (which, pressing with a force proportioned to the height of its column, and to the size of the area of the orifice, separates and opens the parietes of the pore, and expanding the narrow orifices and little passages, urges and intrudes itself thereinto,) cannot but impinge upon the points of the surfaces, entangle itself in their oozy moisture, and deposit and bury therein a miscellaneous medley or farrago of effluvia; whence, after passing through so many sieves and strainers, it comes at length clean and pure to the vesicles (*l*). But on the contrary, *the trachea impregnates with vapors the air that is passing out: thus it entangles effete exhalations, and prevents the contiguous parts from being injured thereby* (*m*).

376. *The trachea likewise in a general manner clears the lungs from viscid phlegm by expectoration.* This is effected by deter-

(*i*) Heister, enumerating the coats of the trachea, terms "the second, glandular" (n. 368). That its glands communicate by excretory ducts or little tubes with the cavity of the trachea, is thus declared by Winslow, "This [internal] membrane," says he, "is perforated by the little ducts of the above-mentioned glandular granules; which discharge a fluid when pressed, and being examined by the microscope appear vesicular or follicular, much like those of the stomach" (n. 369). That the membrane of the posterior part is beset with great numbers of glands, will be seen presently.

(*k*) "These branches [of the bronchia]," says Boerhaave, "lie at acute angles to each other, and become gradually smaller and thinner, till at their extremities they lay aside their cartilaginous nature" (n. 371).

(*l*) This subject will be resumed in the next Chapter, when we come to speak of the Lungs.

(*m*) Respecting this subject also see the Chapter on the Lungs, n. 405.

mining the force and incidence of the air upon any point whatever of the surfaces or parietes, either of the branches, or of the bronchia, or of the trachea, or of the palate, or of the buccal cavity; by means of the application of the external or general muscles of the chest, the neck, the head, the tongue, and other parts; also by extending, contracting, dilating, compressing, or incurvating the tubes, corrugating them by means of their proper muscles, and thus brushing off and clearing away the viscid substance, wherever it is sticking to the surfaces: hence we have expulsion, attended with crepitus and sound from the proper source of sound (*n*); in short, what is commonly termed coughing and expectoration, which are operations performed by an inverse motion, or by a voluntary action contrary to the natural action,—operations analogous to vomition in the stomach, and to eructation in the œsophagus (*o*).

(*n*) From the action of coughing, and thereby of clearing the lungs, the bronchia and the trachea, we see as in a kind of dim image, how sound is raised up; that is to say, how the outburst and as it were extorsion thereof is determined by the action of the external or voluntary muscles. For in the above-mentioned operation of clearing [these parts], the air is similarly directed towards the parietes, and at will to all points of the bronchia or trachea, that are occupied or infested by viscid and mucous matter; and not only is the air directed to these places, so as to strike them forcibly, but the membrane of each particular spot is corrugated, and the noxious substance shaken off by this twofold means. This is by no means effected by the simple action of respiration, or by the transit granted to the air, as during expiration. Hence we may see the difference there is between the natural or respiratory pulmonic action, and the voluntary pulmonic action,—the action of modulating or speaking, and of coughing; also that these motions are conjoined or mixed during the waking state.

(*o*) All the voluntary motions are actions different from natural action, exceeding and extending natural limits, and twisting or straining them in various ways. These limits nature restores, particularly during the time of sleep. The same remark applies to all inverse or insurgent actions, as those which occasionally take place in the intestines, the stomach, and the œsophagus; and which, if they be not excited by voluntary causes immediately, nevertheless are excited by preternatural causes,—namely, by the improper indulgence of the appetites, the

377. II. *The trachea serves as a pillar and support to the larynx; and adapts itself exactly to the beck and nod of the latter, and to its tremulous vibrations;* namely, at the time when the laryngeal tube extends itself, and heightens the sound, and when it contracts, and lowers the sound; in a word, in regulating all the quantities of the voice (*p*): also when the pharynx is acting, and the larynx, quitting its natural situation, is raised or depressed. The trachea is adapted to coöperate and assist under these circumstances; hence the uppermost of its little cartilaginous ribs are stronger, and set nearer together, than the others, and are attached by ligaments to the cricoid cartilage; and the ring next to the cricoid is shorter than those which succeed it (*q*): which peculiarities act as checks to prevent the variation of the sound with respect to quantity from confusing its variation with respect to quality (*r*). In order

unbridled excess of the passions and emotions of the animal mind, or by other similar things, which proceed without the sanction of the higher mind and nature. Whatever proceeds in consecutive order from prior to posterior—*a priori ad posteriora*—flows according to nature's stream; but what proceeds from posterior to prior—*a posteriori ad priora*—too often goes contrary to nature, and does violence to the order of the higher mind.

(*p*) Respecting these particulars see the Chapter on the Larynx, n. 364.

(*q*) "In dissections of the trachea," says Morgagni, "it is not uncommon to find some of its cartilages grown together at the extremities, and some much broader than others. These varieties are more frequent, if there be any difference, in the first cartilage; which not seldom is broader in itself, not seldom is exceedingly broad, in consequence of being united to one, or even to two of the other cartilages. Besides, it is unlike the others in length, and particularly in shape; in fact, I have often found it the shortest [in diameter] of all the cartilages" (n. 370). And Winslow says, "I have observed the first three circles united into one piece, bent alternately in two different places in the direction of its breadth [largeur]" (n. 369).

(*r*) Thus the effect of the elevation and depression of the laryngeal tube, which is the cause of the heightening and lowering of the sound, is communicated only to the anterior part of the larynx, that is, to the thyroid cartilage, and not to the posterior part of the cricoid cartilage, where the arytænoid cartilages are situated: for the posterior or mem-

that the trachea may not be simply under the dominion of the larynx, and passively obey its behests, but also may assist it by reacting, and by acting on its own account, it is furnished with particular muscles of its own, as well as with general muscles (*s*); and to these the thyroid and pharyngeal muscles also lend a secondary aid.

378. *The trachea disposes the parietes of its canal, so that the air may impinge upon them; and stretches or tightens its membrane, so that when the air impinges the membrane may tremble; and thus excites the rudimentary sound, for the larynx afterwards to form into singing or speech, that is, to modify.* This it does by determining the air, by means of the voluntary muscles; and on the other hand, by disposing the cartilaginous and membranous parietes in correspondent opposition to the air; and stretching them in accordance to the degrees or quantities of the quality of the sound (*t*). For the sake of this end or use, the trachea is surrounded with a fine membrane (*u*); next

branous part of the trachea may be at rest, while the anterior or cartilaginous part is elevated or depressed. The variation produced in the sound by the elevation and depression of the posterior part of the cricoid, was pointed out in our explanation of the larynx, and shewn to be so great, that the rima glottidis is entirely closed by the former act, and the exercise of voice or sound interrupted. Respecting the operation of the crico-pharyngæus muscle upon the anterior and posterior parts of the cricoid cartilage, see the Chapter on the Larynx.

(*s*) "The third [coat]," says Heister, "[is] muscular, the fibres of which are transverse, and unite together the two extremities of each ring, and serve to contract them" (n. 368). "The fourth membrane [or coat]," . . . says Winslow, "consists chiefly of two planes, partly muscular and partly tendinous" (n. 369).

(*t*) This coincides with what we said above respecting the clearing of the trachea by coughing (n. 376).

(*u*) Respecting this membrane, Verheyen says, "The internal surface of the trachea is lined by a certain other coat or membrane, coextensive with the tube. . . . This coat is commonly thought to be acutely sensitive; and it is considered to be in consequence of this that the entrance of the smallest crumb into the trachea produces violent coughing. But it appears to me that this coat is lined on the inside with another very fine membrane, to which the sensibility of the part is

to this, with a comparatively strong tendinous membrane; in front, with cartilaginous rings; behind, with two or three coats, extensile, pliable, elastic and vibratory, furnished with fibres both perpendicular and transverse, and continued to the arytænoid cartilages of the larynx, and to the annular cartilages of the trachea, where these coats perform the office of both external and internal perichondrium (*x*). Thus when a tremor is

mainly owing. . . . This membrane, however, to the best of my knowledge, is not described by any author." (*Corp. Hum. Anat.*, tract. iii., cap. xi.)

(*x*) Four membranes are commonly enumerated by anatomists as constituting this aërial or tracheal canal. The two inner ones serve principally to supply the defect in the cartilaginous tube posteriorly: these are the coats that receive the first impulses or strokes of the air, and carry with them the other contiguous coats into accordant tremblings; which tremblings proceed, according to true natural order, from purer to grosser; that is, from the innermost, subtile, thin membrane just spoken of (*u*), to the proximately contiguous, thicker and tendinous membrane; and thence, as well as from the exterior membrane united to the latter, to the annular cartilages, to which both these coats are adherent, and serve as perichondrium. And in order that the determinations may be certain and constant, both towards the cartilages, and from them into the two coats at the posterior part, and from these back again; also towards the arytænoid cartilages and the rima glottidis,—the fibres of one coat are transverse, those of the other, longitudinal; so that the tremor runs out directly on all sides following the continuity of the fibre. This, however, is no proof that the direction of the fibres may not serve for vast numbers of other uses; namely, in extending and stretching the tube; for nature, in all her works, simultaneously intends multitudes of benefits to life; her absolute perfection consists in this design. We have only to read a description of the membranes, to be convinced that their direction agrees with what is here specified. "The fourth membrane," says Winslow, "is that which supplies the defect in the cartilaginous canal of the trachea. It consists chiefly of two planes, partly muscular and partly tendinous, the external or posterior of which is made up of longitudinal fibres; and the internal or anterior, of transverse fibres. . . . The third membrane lies on the inside, adhering closely to the cartilages, and serving them as an internal perichondrium. . . . The second or proper coat [or membrane] is cellular, . . . and the pellicles thereof nearest the cartila-

imprinted anywhere, it glances swift as a ray of light, flying in the manner peculiar to its nature, from circle to circle; from all these, along the transverse fibres, into the field of the posterior membrane; and from this membrane, along the perpendicular fibres, to the organs that modify the sound, that is, to the arytænoid cartilages and to the glottis.

379. *The trachea moistens the larynx continually with a vapory dew*, flowing, during every act of inspiration, from the numerous glandular springs of the lungs, the little tubes, the bronchia, and the trachea, and accompanying the warm air that is going out, in the form of vapor or halitus (*y*). This vapor,

ginous segments serve them for an external perichondrium" (n. 369). Morgagni also figures certain strong fibres continued from the trachea to the bronchia. "The fourth or internal coat," says Heister, "is tendinous and robust, and . . . [has] longitudinal fibres" (n. 368).

(*y*) Many considerations shew, that not only a pituitary but also a limpid humor exudes from the glands of the trachea and bronchia,—both from the common glands, and from the particular and proper glands; consequently it is according to nature, that as the air passes by in a very heated state, it should carry away the more limpid part in vapor,—especially if the membrane should at the same time be vibrating with a strong tremor, and the air, determined against the parietes, be undergoing a repercussion, on all sides. The fact is still more plainly indicated by the moistness of the breath constantly expired from the mouth and nostrils, and which cannot derive the whole of its humidity from the palate alone; but if it does derive humidity from the palate, must of course derive it also from the well-watered and constantly steaming cavities lying underneath the palate. In this manner we may account for the mucosity and density of the humor left in the trachea, and which requires to be brought up, shaken off, and thrown out, by violent efforts of coughing. For if all the impure matter that is being constantly poured forth by the ever-incited glands, were to remain in the [interlobular] partitions and narrow pipes of the lungs, in no long time the passages would be blocked up. Many means of evacuation have therefore been provided, namely, particular means, constantly in action, in the form of the evaporation mentioned above; and general means, returning as occasion requires, in the form of cough and expectoration. That the œsophagus also is one appointed channel for the discharge will be shewn in the sequel. Meanwhile, in this way, the thyroid gland serves for moistening not only the trachea, but also the

as it passes onwards, plentifully irrigates the larynx, and softens it, particularly when it is modulating intently, or speaking with earnestness: thus the trachea spends its exhalations even upon the uses of the larynx.

380. III. *The trachea aids and assists its neighbor, the œsophagus, in the office of deglutition.* For the trachea and the œsophagus, like a married pair, run down side by side, from the palatine fauces, and from the tongue, which latter is set in authority over them both; they recline close together, lying head to head, and lend their mouths to mutual kisses; each holds the other in a fibrous chain, and presses it with a soft embrace. They are associates in office in this respect, that both of them connect and unite higher things with lower,—those things that belong to the head with those that belong to the body: the œsophagus uniting with the head those that belong to the abdomen, and the trachea, those that belong to the thorax (*z*). When the pharynx is rolling down the food through the œsophagus, the larynx and the trachea yield, the latter yielding in its softer or membranous portion all the way to the round tips of the annular cartilages, and going inwards, into its cavity (*a*): and on the other hand, when the larynx and the trachea are respiring strongly, taking deep breaths or making loud sounds, then the pharynx and the œsophagus yield to the same amount: wherefore these organs mutually compress, anoint and enter each other: the one is passive while the other acts, and the larynx and trachea do not so much as utter a tone or a murmur while the pharynx and œsophagus are eating; and *vice versa*: which is the reason why the posterior part of the circle of the trachea, the part next to the œsophagus, is membranous, tendinous, muscular and elastic, and therefore reciprocally passive and active (*b*). Hence nerves from the two brains, that is to

larynx; for what is proper to any one thing, according to nature's constant law, must also be common to all: and its going forth for the public service, is a thing provided for in all kinds of various ways.

(*z*) See Part I., n. 82, the Chapter on the Œsophagus.

(*a*) Respecting the manner in which the larynx closes its passage, and stops the breath, while the pharynx is swallowing, see above, n. 367.

(*b*) We are principally instructed by the influx of the nerves, re-

say, nerves of nature and the will, go to both these organs, and oblige them to mutual compliance: and inasmuch as the

specting the origin of the actions of organs,—whether those actions spring from the cerebrum, or from the cerebellum; consequently whether they are subject to the government of nature, or to the government of the will. Inasmuch as the cerebellum acts under the guidance of nature alone, therefore we may properly term its nerves, natural nerves; or what amounts to the same thing, we may term the actions which result from them, natural actions; but the others may be denominated nerves of the will, and the actions produced by them, voluntary actions. Besides which there are also certain mixed actions, as there are mixed fibres of nerves that enter the organic muscular substances. What is natural and what voluntary, may indeed be perhaps concluded from the nerves themselves, but more surely and plainly from the actions, which are the actual effects. For the nerves of nature, or of the cerebellum, while they are yet tarrying on the threshold of the descent to the trunk of the body, commingle and interweave with each other in the most various ways, and unite by mutual anastomoses; particularly in the ganglia of the intercostal or great sympathetic nerve, the uppermost semilunar ganglion of which, placed in the neck, is entered by nearly all the nerves of the head, and by great numbers of those of the neck; and inside the ganglion, these nerves consociate and intertwine, according to all the modes of operation they are afterwards to execute, and then issue forth in this commingled state: wherefore some fibres of the cerebrum, inserted from the medulla oblongata and spinalis, seem to accompany every branch of the intercostal nerve and par vagum. With respect to the nerves which go to the trachea and larynx, they are branches of the right and left trunks of the par vagum, and spring consequently from nature's fountain, the cerebellum; although they may also contain a number of voluntary nerves; inasmuch as the par vagum, before descending, first plunges into the uppermost ganglion of the intercostal nerve, and perhaps unites therein with many voluntary branches. Certain it is, from the neurological researches of various anatomists, that a particular voluntary nerve, arising from the second cervical pair, runs to the larynx, and supplies its muscles; and this, through the fissure between the thyroid and cricoid cartilages; that is, in the most quiet region of the larynx, and at the general meeting-place of its motions: but that the par vagum reigns over the whole of the tracheal tube, and when it descends beside the larynx, (to its own second ganglion according to Vieussens,—to the second ganglion of the intercostal nerve according to Winslow,) it sends upward a certain nerve,

trachea is carried away by so many motions that are not proper to it,—by an infinity of voluntary and even alien motions,—therefore nature dare not venture too near with her nerve, the par vagum, but first passes by, and then runs back again, and detaches a number of twigs from her recurrent nerve, and cautiously transmits them to, and plants them in, this tube, subject, as it is, to so many inconstancies of the will. The same may be said of the carotid artery, which at first has no offsets, but afterwards reflects a branch, in the manner of an arch, to the larynx.

381. *The trachea also divides and shares the salivary humor*

which proceeding along the trachea, communicates to it an immense number of twigs, and in the larynx meets its fellow-nerve of the opposite side; this nerve, from its course is termed the recurrent nerve. The reason why the trunk of the par vagum dare not come in contact with the trachea, is, because the trachea is subject to such innumerable extraordinary and voluntary motions; namely, every moment when we are speaking, singing, eating, &c. But let us hear Winslow's description of the nerves of the trachea. "The third branch [of the eighth pair]," says he, "passes between the cornu of the os-hyoides and the ala of the thyroid cartilage, and running in between that cartilage and the cricoid, it communicates with the extremities of the recurrent nerve. . . . In its passage it [the large trunk of the eighth pair] gives small branches to the neighboring parts. . . . One of these small branches, in its course downwards, joins a small branch of the second cervical pair, and is distributed to the thyroid gland. . . . As the right trunk passes before the subclavian artery, it gives off a considerable branch, which bends backward under the artery, and mounts up the side of the trachea, to which and to the œsophagus it gives filaments, all the way to the posterior part of the larynx: this branch is the recurrent nerve. This recurrent nerve having reached the larynx, gives branches to its muscles, to the pharynx and thyroid gland," &c. (n. 369). These particulars suffice to shew, how speech, at first ordered by the mind, through the medium of the will, becomes ultimately in a manner natural; namely, in the first instance by the mediation of the branch of the second cervical pair, which conspires with the nerve of speech, or of the ninth pair; and then that the larynx, thus instructed and cultivated, subjects itself gradually to the government of the eighth pair, that is, of nature. But we shall treat further of these subjects in another place.

proceeding from its springs, in just proportion between itself and the œsophagus, according to the necessities of each: the humor proceeding, I mean, both from its common and from its particular springs. The common springs of the trachea are the thyroid and bronchial glands, which are implanted in its tube and covered by its membranes, and united also by visible excretory ducts to the œsophagus (*c*). Its particular springs are the numerous glands scattered and grouped between the coverings or involucra, especially in its posterior part, which abounds with glandular granules (*d*). That the glandular humor of the

(*c*) Respecting the bronchial and thyroid glands, see Part I., n. 81 (*n*), the Chapter on the Œsophagus, where we shewed that those glands also proffer and supply their humors to the œsophagus, to which they are united by visible filaments. "The bronchial glands," says Heister, "are of various sizes, large and small. They are of a blackish color, and are connected to the lower part of the trachea, to the divisions of the bronchia, and to the œsophagus. . . . The thyroid [gland] is large . . . it is connected by its middle part to the superior rings of the trachea, but by its cornua, which run directly upwards on both sides, to the larynx and the œsophagus" (n. 368).

(*d*) Respecting the tracheal glands, which are situated in the posterior or membranous part of the trachea, Morgagni says, "All along the back of the trachea, and of the first branches of the bronchia, where the cartilages are deficient, when the exterior coat is taken off, a great number of glands come immediately into view. These glands are roundish, oval and compressed, and of various sizes" (n. 370). And Heister says, "In one male subject I found many black glands of this kind, adhering to the whole posterior surface of the trachea, near the œsophagus, of a size between a grain of wheat and a kidney bean" (n. 368). See also what Winslow says of these glands, n. 369. Meanwhile, the existence of a communion of humors or salivæ between the trachea and œsophagus, appears to be rendered probable by a number of considerations; for instance, by the fact, that the discharge from the glands in part exudes immediately into the cavity of the tube, in part into the cellular tissue. "The second or proper coat [of the trachea]," says Winslow, "is cellular, and is a continuation of the cellular covering of the lungs" (n. 369). Also by the fact, that such secretion, circulating between the membranes, naturally betakes itself to the quietest place, which is where the tube of the trachea begins to be membranous, or where it lies against the œsophagus; for this part may

trachea, when use requires it, becomes common also to the œsophagus, appears to be rendered highly probable by the neighborliness, proximity, mutual inclination, connexion and coöperation of these two organs; by the action and passion of the one respectively to the passion and action of the other; by the cellular tissue between the membranes of the trachea, and the natural derivation of the fluids through that tissue, from disturbed places and points to more quiet stations; thus from the anterior region, where the annular cartilages are situated, to the posterior, where the continuous membranes are situated; and from thence, by secret ways of discharge, to the œsophagus, as by open ways, from the larger glands. In this manner the trachea performs the office of the grand œsophageal salivary gland.

382. IV. *The trachea pours the alternate respiratory motions of the lungs into the neighboring parts, and thereby into the remote and ultimate parts;* namely, into all those members and instruments of life that pass up and down through the neck, from the supreme and celestial region of the body (*e*) to its inferior and terrestrial region. At the beginning of the ascent, it gifts

have an interval of rest when the cartilaginous rings are agitated up and down. And again from this other consideration, that there are a number of reciprocal passages between the trachea and the œsophagus,—those, for example, leading from the general or thyroid and bronchial glands, respecting which see above, note (*c*). For the states of things are always so ordered by nature, that when a neighboring organ has need of any assistance, it receives this assistance from the organ next to it, or if this be impossible, then from other organs more remote; and this particularly from the trachea, which has marvellous appliances and adaptations for serving all its neighbors. And if we attend carefully to the discharges of the larynx, we shall find that all its humor is not thrown off by either evaporation, or coughing; for sometimes these processes are intermitted for a considerable time, and yet the trachea is constantly cleared, and gives out sharp and natural sound in the interval: so that it is not easy to find any other refuge for the humor than the œsophagus, unless one chooses to consider that it goes all the way to the palate, as we may indeed perceive to be the case if we attend to our sensations.

(*e*) That is to say, from the head and the cerebrum, where the

and inspires them with the motion and spirit [animum] of the body (*f*), but only with a common, not with a special deter-

heaven of the body is situated, and where the soul presides in her own high court and tribunal.

(*f*) In order that we may comprehend distinctly what the body or the corporeal or bodily life is, it is absolutely necessary that we should know its proper essence, afterwards the nature of the determination of this essence, then the nature of the motion of the essence so determined, and whence this motion arises, or what is its source; finally, the nature of the influx and correspondency of the higher with this lower life,—of the spiritual life with the corporeal: these last are objects of psychology, and require to be investigated by the analytic method. But to prevent us from involving our ideas in obscurity, at this first threshold to rational psychology, it is necessary to represent all these points at once and distinctly, although this is a work of time, experience, and the most intense study. The *proper essence of the body* is the blood, which is determined by the vessels,—by the arterial vessels particularly, but also by the venous vessels. The *determinations*, therefore, are the organs or viscera, which are designed and formed by the blood-vessels, and which are the objects of the science of anatomy. *The motions of the essence so determined*, are natural, voluntary and mixed; the natural motions are those of all the organs or viscera, and are excited by the fibres of the cerebellum, particularly by the fibres of the great intercostal nerve and of the par vagum: the voluntary motions are those of all the muscles, which form the circumference of the body particularly, and its appendages, as the arms, the loins, &c. *The source of natural motion* is the cerebellum; but [the source of the motion] of the blood itself is the great heart of the body, with its arteries and branches, which latter correspond to the heart as the head of these motions. *The source of voluntary motion* is the cerebrum, and as allied and associated with it, the lungs: although the lungs are not only the source of the voluntary motions, by their association with the cerebrum, but they are in a manner the source of even the natural motions, by their association with the cerebellum; consequently their sources of motion are, properly speaking, mixed,—one source ruling in the day-time, the other, during the night. *But the nature of the influx and correspondency of the higher with this lower life,—of the spiritual life with the corporeal*, must furnish a subject for our Psychology. Meanwhile, the lungs are the organs which inspire the body with its motion, and enable it to live: for the determination of the essence of this life is not of itself sufficient; there

mination (*g*). Specifically, it inspires these motions *into the œsophagus, and thereby into the stomach, and so into the viscera of the abdomen;* which latter depend from their stomach, and are turned by it, and the stomach by its œsophagus, as straps by a wheel, and the wheel by its axis (*h*): wherefore the trachea reclines beside the œsophagus as a close companion or fellow-traveller, all the way from the palate, the root of the tongue, or from the os-hyoides,—thus from the last point of the supreme region,—through the neck, between the two pleuræ of the mediastinum, as far as the arch of the aorta, thus to the first threshold of the inferior region (*i*); and through the whole of the

must also be a continual excitation to action of the life so determined: the exercise of life consists in bodily action.

(*g*) The common office of the lungs is the proper office of the trachea; hence simply to excite motion is the office of both the lungs and the trachea; but to determine it specifically, so that, together with the motion of the brains, it may concur in a general manner to every action,—this is the proper office of the lungs, and not of the trachea.

(*h*) Respecting these subjects, see Part I., the Chapters on the Œsophagus, the Stomach, and the Peritonæum; where it was shewn that the œsophagus flows into the stomach, not only with its coats, but also with its activities; consequently with the alternate pulmonic motion, which it receives from its companion, the trachea, during every moment of respiration; and as often, by its coats and by the nerves which it conveys to the stomach, propagates, and renders in a manner habitual and natural, to that viscus; and since to the stomach, therefore also to the viscera of the whole of the abdomen, which are set in action by the stomach, as being the straps or little wheels of the abdominal machine, [of which the stomach is the grand wheel]: this effect being aided by the peritonæum, which actuated by the lungs, by means of the diaphragm, flows into the same viscera with a similar vicissitude of motions, and thus, together with the stomach, obliges them to yield compliance to the motions of the lungs.

(*i*) The trachea, according to Winslow, "runs down into the thorax, between the two pleuræ, through the upper space left between the duplicature of the mediastinum, behind the thymus gland. Having reached the curvature or arch of the aorta, it divides into two lateral parts termed bronchia" (n. 369). Thus the trachea is made over and bound to the lungs by two bonds; namely, by its continuation to the innermost parts of the lungs in the form of little tubes, perpetually

same course is connected to the œsophagus by social bonds (*k*), and infuses into it the alternate motions of the lungs, during each of its own alternations. *Also into the great sympathetic nerves,—the intercostal and the par vagum,* which pass down on both sides of the trachea, and by numerous branches of their recurrent nerves, all so many means of connexion, are associated and united to it (*l*): and thus it inaugurates these strangers,

ramifying, subdividing, and multiplying: also by its continuation to the outermost parts of the lungs by means of the membranes, principally of that next the common membrane, and of the cellular membrane, and also by means of the mediastinum, which is reflected around the lungs as a continuation of the pleura. Thus not the smallest action can possibly take place in the lungs, without being communicated to the trachea, and carrying it away in the same manner as the lungs.

(*k*) It is well known that the trachea not only leans against the œsophagus, but also is connected to it throughout; in the same manner as the pharynx of the œsophagus is connected to the larynx of the trachea by the crico-pharyngæi and thyro-pharyngæi muscles; also by the tubular filaments proceeding from the thyroid and bronchial glands. The trachea is "connected," says Heister, "with the fauces, the lungs, and the œsophagus. . . . The bronchial glands . . . are connected to the lower part of the trachea, to the divisions of the bronchia, and to the œsophagus" (n. 368).

(*l*) It was pointed out above, that the great sympathetic nerves dare not approach too near to the larynx, because, inasmuch as they arise from the cerebellum, they are nerves of nature, and keep all things in constant order, and reduce all voluntary motions thereto; and because the motions of the trachea are most inordinate,—subject every moment to the actions of the lungs, of the larynx, the œsophagus, and all the muscles of the tongue, the os-hyoides, the palate, and even of the head, the neck, and the thorax. On these accounts, the sympathetic nerves send upwards and backwards a certain branch, termed the recurrent nerve. This nerve detaches from its little trunk a number of branches, and puts them prudently and cautiously into the trachea; these branches being so many lines or paths, by which the pulmonic or respiratory motion of the trachea is communicated to these two universal nerves of the body. Consequently, when the trachea insinuates these motions into them, they necessarily transfer the motions into their viscera, which they intimately penetrate and even constitute: but only in common; for all their fibres bring this same motion with them from

and thereby the innermost parts of the viscera, into this vital motion of the body. *Likewise into the ascending carotid artery, and the descending jugular vein,* which enclosed together with the great nerves just mentioned, in a kind of cellular, fibrous, and membranous sheath, likewise pass on both sides not far from the larynx (*m*), uniting themselves to it by branches, and being thus linked with it in one common design. In this way, moreover, the trachea brings the respiratory motions of the lungs into consociation and unison with the animatory motions of the

the cerebellum, and thus implant it in the viscera. But wherever the particular is present, there the general must also be, in order that a certain and inevitable effect may result from the correspondence of both. See Winslow, n. 369.

(*m*) The carotid artery, emerging freshly from the trunk of the aorta, and beginning its ascent, brings with it the motion of the aorta and heart; but in order that it may be initiated into the motions of the brains and lungs, it runs at no great distance from the larynx; yet on account of the inconstancy of the latter's motions, the aorta, like the par vagum, does not venture to touch it, but mounts up straight and branchless until it rises above and beyond the trachea and the larynx, and then puts forth its first branch, and curves it back towards the larynx and trachea. Thus the carotid artery, the jugular vein, and the two nerves,—the intercostal and the par vagum,—are kept constantly in the stream of this motion, that is, of corporeal life; for they run not far from the trachea, enclosed together in the same sheath or capsule. "Through all this course," says Winslow, "this trunk [of the par vagum] is invested by a kind of cellular, filamentary, or membranous sheath, common to it with the internal carotid artery, the internal jugular vein, and the great sympathetic nerve. In its passage it gives small branches to the neighboring parts," &c. (n. 369). The reader will find these points delineated by Morgagni, *Advers. Anat.* v., tab. ii., fig. 1. I am aware that the carotid artery and the nerves keep close to the cervical vertebræ, and are not exactly beside the larynx; but inasmuch as in this case they are near the œsophagus and the pharynx, therefore the operation of the larynx must necessarily be transferred to them, by means of the œsophagus, the mediastinum, and the pleura: and if these are disposed to the pulmonic motions by the trachea immediately, then the trachea is the cause of the effect, because it is the cause of the cause.

brains (*n*). *Thus the trachea renovates the motive life of the body;* which motive life, were it not for the above social compact between the brains and the lungs, would be similar to our first life in the ovum and womb; in other words, it would be complete in potency, but very defective in endeavor, and nothing at all in act (*o*).

383. V. *The trachea insinuates into the neighboring parts, and thereby into all other parts, high and low, its own sonorous tremblings, as well as those of the larynx: thus it excites the arterial blood mounting to the head and brain, and exhilarates and animates it by a general modification.* The trachea does this by communicating its tremor to every particle of the blood, by means of the membranes, nerves, and vessels, and by means of

(*n*) Respecting this coincidence of motions,—of the animatory motion of the brains with the respiratory motion of the lungs,—see the Part on the Cerebrum. The larynx appears to be a uniting medium between these motions, and both by its motive and sensual powers, (of which latter we shall speak in the next paragraph,) communicates with the vessels proceeding to the brains, and with the vessels and nerves coming down from the brains.

(*o*) It is very evident from mere experience, that no voluntary motions or actions can be produced without the correspondence and assistance of the lungs. How the lungs conspire to particular actions, we may all perceive by a little reflexion upon what passes in our own persons, and by considering some of the actions specified above (n. 374): also by the case of uterine life, before the opening of the lungs, in which state the power of acting exists in all the muscles and members, and yet no action follows the power. But the confirmation of the experience of these matters by reason, and of the reason by experience, is a subject for another place. Thus much is plain,—that the lungs contribute in a general manner to all actions, both natural and voluntary, and by their determination excite the nerves, and trunks of nerves, to act in one particular way, and in no other: while the cerebrum and cerebellum do the same, not only in general, but also in every particular; thus the lungs influence the stomach, by means of their own action and that of the trachea, directed upon those great nerves which flow along the œsophagus to the stomach. Hence the trachea with the lungs renovates the motive life of the body. But you will see these particulars more fully explained in the following Chapter, on the Lungs.

the sheath in which the carotid artery, the jugular vein, and the two sympathetic nerves are jointly enclosed in their ascent (*p*). *Likewise the venous blood returning from the head and brain, together with the ear, the companion in office of the trachea.* For the jugular vein comes out of the chamber of the cerebrum in company with the par vagum, through a foramen or foramina [foramen lacerum posterius] common to the two, in the petrous portion of the temporal bones, where the ear with its harmonic instruments is lying underneath in its carved recess, and where the tented web and membrane is perpetually trembling in coincidence with the sonorous modulations of the ear (*q*). From this place the vein passes rapidly down to the larynx and trachea, thus into a second field of sonorous tremors, exhibiting in its course a manifold play of ramifications, and forming frequent anastomoses with its fellow internal vein of the opposite side, and with its kindred external vein (*r*). Thus this venous

(*p*) See above, note (*m*).

(*q*) There is a certain tract within the cavity of the cranium, bounded by the sinuses, particularly by the ultimate or lateral sinuses and their receptacles, which I think may properly be termed the sonorous tract: for the petrous portions of the temporal bones subtend it; and the ear lies below it, hidden in its carved recess; the portio dura of the seventh pair there goes up into the ear; and the jugular fossa opens in the same situation, and affords a common passage to the jugular vein and the eighth pair of nerves. This tract is particularly capable of trembling, being constructed of petrous, squamous, and cellular bones, and influenced moreover by all audible vibrations. Thus the jugular vein and the par vagum, from their very cradles, are introduced into the nature of the tremors of this sense: and as they pass down, they fall into a similar sphere, that is to say, to the very sources and active powers of sound, namely, over the larynx and trachea; which sphere likewise communicates with this same nerve, and with the jugular vein as it issues from the cranium, by means of the Eustachian tube.

(*r*) The two jugular veins form very remarkable anastomoses upon the trachea, which are admirably figured by Eustachius, *Tabul. Anat.*, tab. x., fig. 1, 2. Winslow also makes some mention of these anastomoses. "Posteriorly," says he, "it [the external anterior jugular vein] gives off a large branch on the side of the upper part of the larynx, which communicates with the internal jugular; . . . and below the larynx it

blood, deprived in the cerebrum of its spirit, of its finer life, and power of fluidity, and hence become lifeless, slow and dull (s), would die of languor, unless a certain tremulous agitation, expansion and constriction invaded its particles severally, dashed them together, plucked them asunder, shook off their torpor, and sandalled them with fresh wings. By accomplishing these results, the larynx and trachea put this blood in a state of

sends communicating branches to the external anterior jugular vein of the other side" (n. 369). In fact, a number of twigs pass into these very communicating branches: so that the tremor collected by all, and multiplied on the way until it reaches the subclavian vein, increases in a greater degree than the veins themselves in their expansion into trunks.

(s) For the blood that is fuller of life and more rich in spirits, is raised up towards the cerebrum, and expended and immolated for its purely organic or cortical substances, which reclaim and emunge the spirit of their blood, and ultimately send it forth in a kind of high circulation through the fibres, as we shall shew by an abundance of experimental proofs in the Part on the Cerebrum. Wherefore the blood bereft of its spirit, and comparatively resisting, hard and livid, and consequently sluggish, (because deprived of its spirit or principle of fluidity,) is rejected into the sinuses through the little veins. This blood is refected by a portion of new spirit, in the ultimate receptacles of the sinuses, as will also be explained in our Analysis in the same Part. But with the effete blood the spirit can celebrate no nuptials; hence in order that the languid blood may be excited, and the fresh spirit exhilarated, they are both led into this sonorous or tremulous field of the larynx and trachea. The effect that results from so lively and sensible a trembling, infused into fluid parts, may easily be concluded from phenomena, as well as from rational considerations; especially if we are inclined to infer the effect from causes, and their modes of action. For the modification of the air, which is perceived by the ear as sound, consists in the stroke of one particle against another, whereby these perfectly elastic particles are suddenly compressed, and again expanded, which goes on from part to part, until it is diffused over the whole of the adjoining atmosphere. Now supposing that the particles of the blood are assailed by a similar force, then of course this will give rise to a mutual action of one particle against another; consequently to a compression and expansion of each, and thus to a separation of those that are sticking together, to a discussion of incon-

preparation and animation, by a kind of nuptial tune and song, for its approaching marriage and new coition with the chyle of the thoracic duct (*t*). *Thus the trachea renovates the sensual life of the body;* which life derives its existence from modifications; for only take away life from sensation, and what remains is modification, more or less simple or compound according to the substances which it pervades: wherefore sensation, like modification, may be either innermost, middle, or outermost, the last variety being sensible in the form of sound, in the larynx, the trachea, and the ear (*u*).

384. VI. *The trachea represents in itself, as in an image, how every member of this body or kingdom lives for all the other members, and not for itself alone.* This is clearly evident from the wide extension of its benefits and operations, and their communication to the universal organic system; there being nothing

gruities in the particles themselves, and to an incitation of them all to motion.

(*t*) For where the jugular vein falls into the left subclavian, there the thoracic duct goes in with its new chyle; as shewn in our Chapter on the Thoracic Duct. Now since every tremble is multiplied and increased all the way from the first emergence of this vein from the cranium, and afterwards in its passage beside the larynx and trachea, all the way to its termination, where it enters the subclavian, therefore it follows that in the latter situation the tremble is most intense, and excites with the most active force both the descending blood and spirit, and the chyle itself, by perpetual minute vibrations: hence the chyle obtains a power of copulating intimately with the spirit that has come down from the cerebrum with the blood, and enjoying as it were the first delights of marriage. But all these statements are conclusions from premises which are yet to be laid down, and which must be proved for the first time in our Analysis of the Cerebrum; namely, that the venous blood of the cerebrum is almost lifeless, and that new spirit flows into it as it is leaving the cranium. Assuming these points in the meantime, and granting the common tremble above alluded to, we have then the effect as laid down in our proposition. Yet inasmuch as numerous and multiplied means and causes concur to one effect, therefore we cannot assign a higher office to this tremble, than that of a subservient cause.

(*u*) These points will be treated fully in the Part on the Cerebrum and Sensoria, and in the Doctrine of Modifications.

proper to the trachea that is not also common to all the members: the consequence of which is, following the principle of reciprocity and mutuality, that nothing is proper to any member in this great society, that does not yet in turn go forth for the interest and advantage of that society. In this kingdom, the cardinal life of every organ, or the excellency of its life over that of other organs, consists in the fact, that whatever it has of its own, still in a wider sense belongs to the community, and whatever afterwards results from the community to the organ, is the only individual property which the latter claims.

CHAPTER IV.

THE LUNGS.

385. HEISTER. "The lungs are the largest viscera of the thorax, and are situated in the two sides of the cavity, having the heart as it were in the midst of them. They are connected, 1. With the sternum and vertebræ, by means of the mediastinum. 2. With the heart, by means of the pulmonary vessels. 3. With the trachea. The color of the lungs in infants is a fine florid red; in adults and old subjects it is bluish, or variegated with black and white. Their figure, when they are inflated, somewhat resembles that of an ox's hoof; it is convex superiorly, concave inferiorly. They are divided into two great lobes, (termed by Celsus, fibres,) a right and a left; the left lobe, which is the smaller, is divided into two others; and the right, which is the larger, into three; and each of these is again divided into innumerable little lobes. The membrane surrounding the lungs is continuous with the pleura. The pulmonary substance, named substantia spongiosa by Celsus, substantia vesiculosa by Malpighi, is entirely made up of minute vesicles of a fleshy texture, and of various vessels. These vessels are, the bronchia, the pulmonary artery and veins, &c. The bronchia are composed at first of imperfect rings, but in their progress, of cartilaginous pieces variously united, and of contractile membranes: they arise from the trachea, and dividing first into branches, then into innumerable twigs, finally terminate in the minute vesicles before mentioned. These vesicles, forming a principal part of the substance of the lungs, leave between them interstices which communicate with each other, and they seem to adhere to the little branches of the bronchia in the manner of clusters of grapes. The pulmonary artery and vein are divided almost in the same manner as the bronchia, and accompany them throughout their course, although in different ways in different parts, and at length by their ultimate ramifications about the vesicles, they

form what is called the rete vasculosum Malpighii. These vessels do not serve for the nutrition of the lungs, but for the circulation of the blood through them. (*Comp. Anat.*, n. 258.) It has been a matter of discussion with some anatomists, why the pulmonary artery is larger than the pulmonary vein, whereas in all other parts, the veins are larger than the arteries. Some have supposed this to be the case because the blood is unduly separated or expanded in the artery, and is compacted again, or condensed in the lung, by the act of respiration, and consequently requires less space in the pulmonary vein than in the pulmonary artery. But putting aside the opinions of others, I imagine that the artery is larger here, because the blood returning to the heart is too thick to pass with freedom through the exquisitely fine vaccular rete of the lungs; and its retardation and powerful resistance in this part gives rise to a distension and dilatation of the artery. On the other hand, the blood of the pulmonary vein has no obstacle of any magnitude to resist or impede its motion; but having been previously fined in the lungs, may flow freely into the left cavity of the heart, and hence the vein is smaller or narrower than the artery. I ought to indicate here, by way of supplement, that I have hitherto neglected to mention a capsule or tunic, admirably described by Lancisi a short time since, which is continuous with the pericardium, and encases the vessels of the lungs, that is, the pulmonary artery and vein, and the bronchia, both outside the lungs and in their substance, in the same manner as the capsule of Glisson encases the vessels of the liver. (*Ibid.*, not. 41.) The vessel, commonly called the bronchial artery of Ruysch, is dedicated to the nutrition of the lungs; it arises by one, two, or even three trunks, either from the aorta, or from the intercostal arteries, and is throughout closely adherent to the bronchia. The bronchial vein arises either from the intercostal veins or from the vena azygos. (*Ibid.*, n. 258.) I had often sought without effect for the bronchial veins in the human body; at length, in the year 1719, I saw them clearly and distinctly for the first time in a female subject: they ran in several branches from the intercostal veins to the bronchia; three of these branches were very observable, being about the thickness of fine straws: they are not, however, always to be met with. Cowper asserts that he has often seen one or more of them running to the subclavian veins. For further information on this head, the reader may consult Morgagni, *Epist. Anat.* i., n. 90, where he mentions among other particulars that Galen has written upon the subject of the bronchial vein. (*Ibid.*, not. 42.) The nerves of the lungs come from the thoracic plexus of the par vagum and intercostal nerve. Their lymphatics run to the thoracic duct. (*Ibid.*, n. 258.)

386. "The muscles of respiration serve to dilate and contract the chest. The dilators act conjointly. They are, 1. The diaphragm, which has been already treated of in its place. 2. The intercostals, which are forty-four in number; in each interstice of the ribs there are two, one external and one internal. They arise from the inferior margin of the superior rib, and are inserted into the superior margin of the succeeding rib. The fibres of the external muscles run forwards, those of the internal, obliquely backwards: the intercostals serve to elevate the ribs. 3. The levator costarum of Steno, the supercostales of Verheyen, are of two kinds, distinguished from their figure into short and long. The short muscles are twelve on each side; they arise from the transverse processes of the first eleven dorsal vertebræ, and of the last cervical vertebra, and are inserted obliquely into the posterior part of the ribs. The long muscles are three or four in number; their origin is the same from the seventh, eighth, ninth and tenth vertebræ, and they are inserted into the ninth, tenth, eleventh and twelfth ribs. 4. The subclavius arises from the lower part of the clavicle, near the acromion, and is inserted into the anterior part of the first rib, and into the sternum. The serratus posticus superior arises by a thin broad tendon from the two last cervical and the two first dorsal vertebræ, and is inserted into the second, third and fourth ribs. 6. The serratus major anticus is classed by most authors among these muscles; but since the scapula is more moveable than the ribs, therefore, in my opinion, this muscle belongs more properly to the scapula. However, I do not deny that it may assist in elevating the ribs, particularly in cases of difficult respiration. 7. The scalenus colli.——The constrictors or depressors, not including the muscles of the abdomen which are of this character, are, 1. The serratus posticus inferior; this muscle arises by a broad tendon from the three last dorsal and the two first lumbar vertebræ, and is inserted into the four inferior false ribs, and surrounds the extensors of the back in the manner of a sheath, so as to prevent their fibres from being separated from each other during violent motions. 2. The triangularis sterni, arises from the lower and inner part of the sternum, and is inserted on each side into the cartilages of the fourth, fifth, sixth and seventh true ribs. Verheyen divides this muscle into several, and calls them sterno-costales: some authors, on the other hand, deny its existence, but without good reason, for in general it is very easily found. 3. The inter-costales of Verheyen are seen when the pleura is removed; there are six, seven, eight, or nine of them on each side; they arise not far from the heads of the ribs, and ascending obliquely, are inserted into some one of the superior ribs, sometimes into the rib immediately above their point of origin,

sometimes into one of the other ribs. . . . 4. The extensor lumborum et dorsi communis concurs also in depressing the ribs; for it arises from the sacrum, and is inserted by a number of tendons into the posterior part of the ribs." *(Ibid.*, n. 330.)

387. Winslow. "The lungs are two large spongy bodies, of a reddish color in children, grayish in adult subjects, and bluish in old age, filling the whole cavity of the thorax, one being seated in the right side, the other in the left; parted by the mediastinum and the heart, and of a figure answering to that of the cavity which contains them; that is to say, convex next the ribs, concave next the diaphragm, and irregularly flattened and depressed next the mediastinum and the heart. When the lungs are viewed out of the thorax, they in some measure resemble an ox's foot, with the forepart turned to the back, the hinder part to the sternum, and the lower part to the diaphragm. They are distinguished into the right and left lung; and each of these, into two or three portions called lobes, of which the right lung has commonly three, or two and a half, and the left lung, two. The right lung is generally larger than the left, conformably to the right cavity of the chest and to the obliquity of the mediastinum. At the lower edge of the left lung, there is an indented notch or sinus, opposite to the apex of the heart, which is, therefore, never covered by that lung, even in the strongest inspirations, and consequently, the apex of the heart and pericardium may always strike immediately against the ribs; the lungs not surrounding the heart in the manner commonly taught. This sinus is expressed in Eustachius' *Tabulæ Anatomicæ*. The substance of the lungs is almost all spongy, being made up of an infinite number of membranous cells, and of different sorts of vessels, spread among the cells in innumerable ramifications. This whole mass is covered by a membrane continued from each pleura, which is commonly said to be double; but what is looked upon as the inner membrane, is only an expansion and continuation of a cellular substance, which shall be adverted to presently. The vessels which compose part of the substance of the lungs are of three or four kinds,—air-vessels, blood-vessels, and lymphatics, to which we may add nerves. The air-vessels make the chief part, and are termed bronchia. These bronchia are conical tubes, composed of an infinite number of cartilaginous fragments, like so many irregular segments of circles, connected together by a ligamentary elastic membrane, and disposed in such a manner as that the lower easily insinuate themselves within those above them. They are lined on the inside by a very fine membrane, which continually pours out a mucilaginous fluid; and in the substance of the membrane are a great number of small blood-vessels, and on its convex side, many

longitudinal lines which appear to be partly fleshy, and partly made up of an elastic substance of another kind. The bronchia are divided in all directions into an infinite number of ramifications, which diminish gradually in size; and as they become capillary change their cartilaginous structure into that of membrane. Besides the minute extremities of this numerous series of ramifications, we find that all the subordinate trunks from the greatest to the smallest, send out from all sides a vast number of short capillary tubes of the same kind. Each of these numerous bronchial tubes is widened at the extremity, and thereby formed into a small membranous cell, commonly called a vesicle. These cells or follicles are closely connected together in bundles; each small branch producing a bundle, proportionable to its extent and the number of its ramifications. These small vesicular or cellular bundles are termed lobules, and as the great branches are divided into small branches, so the great lobules are divided into several small lobules. The cells or vesicles of each lobule have a free communication with each other, but the several lobules do not communicate so readily. The lobules appear distinctly to be parted by another cellular substance, which surrounds each of them in their whole extent, and fills up the interstices between them. This substance forms likewise a kind of irregular membranous cells, which are thinner, looser, and broader than the bronchial vesicles. It is dispersed through every part of the lungs, and forms cellular or spongy sheaths which surround the ramifications of the bronchia and blood-vessels, and is afterwards spread over the outer surface of each lung, where it forms a kind of fine cellular coat, joined to the general covering of that viscus. When we inflate this interlobular substance, the air compresses and flattens the lobules; and when we inflate the bronchial vesicles, they presently swell, and if we continue to blow with force, the air passes insensibly into the interlobular substance. We owe this observation to Helvetius. All the bronchial cells are surrounded by a very fine reticular texture, consisting of the small extremities of arteries and veins which communicate every way with each other. The greatest part of this admirable structure is the discovery of the illustrious Malpighi. The blood-vessels of the lungs are of two kinds; one common, called the pulmonary artery and veins; the other proper, called the bronchial arteries and veins. The pulmonary artery goes out from the right ventricle of the heart; and its trunk having run almost directly upward as high as the curvature of the aorta, is divided into two lateral branches, one going to the right, called the right pulmonary artery, the other to the left, called the left pulmonary artery. The right artery passes under the curvature of the aorta, and is consequently larger than the left: they both run to the

length; but it contracts again by means of its elastic membrane as soon as the force is taken off. When we open lengthwise any portion of the pulmonary artery and vein in the same lung, we meet with a great number of transverse rugæ, which are obliterated when these vessels are elongated. This is an observation made by Helvetius. . . . These three vessels [the bronchia and the pulmonary arteries and veins] lie in a sort of cellular sheath, which accompanies all their ramifications, and is a continuation of the interlobular cells, or cellular substance in the interstices of the lobules. The pellicles which compose it are, however, disposed there in a more regular manner, and more longitudinally than in other places, and thereby appear to form a true sheath. When we blow through a pipe introduced so far as to touch immediately a trunk of the blood-vessels or bronchia, the air runs at first through all the cells that lie nearest that trunk or its branches; but if we continue to blow, it insinuates itself through the whole interlobular tissue. . . . As the bronchia penetrate into the substance of the lungs, they gradually lose their cartilages; but the muscular lines or columns of Morgagni appear as much, and sometimes more, than before. The two planes above mentioned continue likewise to be visible; and we may observe very distinctly, sometimes even without a microscope, a great many small holes in the pedicles of the lobules, and of the bronchial cells, that is, of the vesicles that immediately surround the bronchia, which holes open from within outwards." (*Ibid.*, n. 135—148.)

388. MALPIGHI. "I have discovered by careful examination, that the whole mass of the lungs, which is appended to the outgoing [excurrentibus] vessels, is an aggregation of very fine thin membranes, extended and folded into almost an infinite number of orbicular and sinuous vesicles, as the wax in honeycombs is extended into sides and surfaces, so as to form cells. These vesicles are so placed, and so connected, that they communicate freely with the trachea as well as with each other, and terminate at last under the containing membrane. This may be demonstrated in lungs just torn from animals and full of air, when almost an infinite number of vesicles, full of air, will be seen on the external surface; and similar vesicles may also be observed when a section of the lungs is made through the middle, and the air let out; although in this case the vesicles are smaller and less conspicuous. They are better and more clearly found in a lung that has been inflated and dried; for we then see little round protuberances on the external surface, and wherever a section is made, we find holes or pits, and sinuous channels and ramifications formed by the extension of a thin membrane. But to remove all doubt, you should tear the lungs from a living animal, and injecting water through the pulmonary artery, drive

out the whole of the blood, and wash the pulmonary vessels; whereby you will immediately whiten and render transparent all that part of the substance of the lung where the water has penetrated, and from which the blood has been removed. If now you slightly compress the lung, so as to drive out the water, and then inflate the lung through the trachea, and when blown up, dry it either in the shade or the sun, you will find not only that it shews these transparent spherules externally, when held up to the light, but that it plainly exhibits a white mass of vesicles when a section is made internally. . . . Here one point presents itself for investigation; when a small piece of the external substance of the lungs is held up against the light, we see a singular network or rete mirabile, by which you would say that the rising and protuberant vesicles are all bound and held together; and the same rete is observed in the interiors of the lungs when a section is made, although in this case less distinctly. I am in doubt whether this rete be vascular; whether it be a nervous substance extending to the vesicles; or whether it consist only of the membranous parietes of the vesicles, terminating at the external investing membrane. . . . I think it not unlikely that it is a nervous ligament, united to and intermingled with the parietes of the vesicles, [connecting them] in the same manner as we see the cartilaginous semicircles are connected in the trachea; particularly since there is reason to suppose that the vesicles are productions of the internal membrane of the trachea.

"The division of the pulmonary mass generally is taken from its figure and situation: thus it consists of two parts, separated from each other by the mediastinum; and each of these again is frequently subdivided into two lobes, in the human subject particularly; but in animals, into a greater number of lobes. I have also observed a more intimate and remarkable division than the above,—namely, that the masses of the lungs are made up of innumerable lobules or little lobes, each surrounded by its own membrane, furnished with common vessels, and growing to the ramifications of the trachea. These lobules may be demonstrated, if a partially-inflated lung is held up to the sun, or to the light; in which case we shall see certain transparent interstices, and by following these interstices, and occasionally using the knife, we shall obtain the lobules in a separate form, adherent on both sides to the trachea and to the vessels. . . . The figure and position of the lobules vary according to circumstances; for since the trachea with the vessels appended to it ramifies on all sides like a tree, and its ramifications terminate at one time upon the external surface of the lungs, which requires to be flat and even; at another time, in their angular extremities; again, since the ramifications must be fitly connected to

the contiguous and surrounding ramifications, so as to preserve their proper position, connexion, equable capacity and proportionable interstices,—therefore the lobules are placed variously, being in some instances united to the trachea by their bases; in others, by their sides; in others again, by their apices. We see an external similitude to these processes in the fruit of the cypress tree. . . .

"After the lobules we come to the interstices mentioned above, but which are not always mere cavities, or circumscribed empty spaces; but many of them contain membranes, sometimes parallel to each other, sometimes lying at different angles; which membranes proceed not only from the external surface of the lobules placed laterally, but also from their internal substance. Between these membranes run a vast number of most minute vessels, coming from the lobules, and which go to the opposite lobules. The air is received and thrown out by these membranes, as it were by large intercommunicating cavities, and hence it may be squeezed from one into another; which shews that the interstices themselves consist of the membranous vesicles of the lungs, but which are here transparent and very thin. . . .

"After injecting ink [aquam nigram] through the pulmonary artery, I have frequently seen it escape from many parts; thus, on slight compression, it exudes in part from the investing membrane, and collects in part in the interstices, but the greater portion comes out mixed with blood through the pulmonary vein; and what is remarkable, it issues in a diluted state and of a lighter color through the trachea, accompanied with a thin froth; this takes place every time the lungs are squeezed. When the same lung is dried, all the parietes of the vesicles and cavities are found to be blackened. Something of the same kind appears to take place when mercury is injected; thus after the pulmonary artery is filled, the mercury runs to the most external bifurcated ramifications, and if these are slightly compressed, it exudes from the external membrane, and sometimes makes its way into the interstices, so that almost the whole of it collects therein. . . .

"The lungs of fishes are in the form of gills or branchiæ: these branchiæ are made up of several semicircles beset with radii, and lying one upon another. The pulmonary vessels, by their minute ramifications, run all the way to the apices of the radii, which are so disposed as on every side to receive the water, the consistence of which is greater than that of air; thus when the water is forcibly compressed by the osseous covering, it so narrows and contracts the radii, that a sufficient commixtion and motion is produced in the ramifications of the vessels, and in the humors that they contain. Furthermore, inasmuch as mucus may be always rubbed from the gills with the greatest ease, it is not

inconsistent to suppose, that what in other animals goes out by the kidneys and the skin, is thrown off in fishes by this compression. *(De Pulmonibus Epistola* i.)

389. "When the abdomen of a frog is opened lengthwise, the lungs come in view, adherent to the heart on both sides. They do not immediately become flaccid as in other living creatures, but continue tense at the will of the animal. The frog's lungs are nothing more than a membranous bladder, which at first sight appears to be sprinkled over with minute spots, set in rows, like the spots upon shagreen. In its figure and external protuberances each lung resembles a pine cone. It is held together within and without by a tissue of vessels, ramifying in various ways, and which, judging from their pulse, their contrary motions, and their insertions, are the pulmonary veins and arteries. In its hollow or internal part it consists almost entirely of an empty space, intended for the reception of the air; nevertheless, it is not smooth all over, but interrupted by various channels, which are formed of the membranous parietes carried up to some little height. These channels, however, are not all of the same figure, for sometimes the parietes are elongated, widened and connected, so as to form nearly hexagonal cavities. At the corners of the cavities, when the membrane is a little inflected and extended, a kind of infundibulum is formed. Such is the constitution of the lungs in the lesser frogs. . . . The blood, driven by the heart's impulse, rains down in the manner of a vapor or effluvium into the minutest parts [per modum effluvii in minima depluit], running through the arteries into all the cells, by one or another of the considerable branches that pass through them, or terminate therein; and thus divided and subdivided, it puts off its red color, and following a sinuous and circuitous course, is scattered on all sides, until it reaches the parietes and angles [of the cells], and the reabsorbent branches of the veins. . . . Under the microscope, the abovementioned spots no longer appear like the spots upon shagreen, but as implicated circles of vessels. . . . In the oblong lung of the tortoise, which like that of the frog is membranous and transparent, it was very evident that the blood ran in a divided state through the tortuous vessels, and was not effused into the intervening spaces; in a word, that it always passed through little tubes, and was thrown about in a complex interlacement [flexu] of vessels. . . When a ligature is put upon the [frog's] auricle and heart, and the motion and impulse prevented that might otherwise be communicated by the heart to the vessels, still the blood is sent by the veins towards the heart, so as by its force and quantity to distend the vessels; and this lasts for several hours: but at length, especially if the parts be exposed to the rays of the sun, the blood ceases to be actuated

with the same continuous motion, and fluctuates, as if impelled fits, going backwards and forwards the same way; which will occur even when the heart and auricle are torn off.—From certain circumstances . . we may infer, that the rete which I before supposed to be a nervous ligament, intermingled with the vesicles and cavities, serves rather as an afferent and efferent vessel for the mass of the blood." *(De Pulmonibus Epistola* ii.)

390. MORGAGNI. "The lung of the viper is simple, that is to say, it consists of one oblong lobe, evidently constructed in the first place of innumerable little bladders or vesicles, opening all over it like the cells of a honeycomb; in the second place, of one large continuous bladder. *(Advers. Anat.* v., Anim. 29.) In a lamb, the artery was beneath the left bronchium, the vein above it; on the right side, on the contrary, the artery was above, the vein beneath; but in such a manner that neither bronchium was exactly intermediate between the two vessels. This will be more clearly seen from what I am about to state respecting the human lung; previous to which I ought to apprize the reader, that even when speaking of the lamb, I have considered the part nearest to the head as above or superior; that nearest to the belly as below or inferior. In one human subject, then, the vein on both sides was above the bronchium; but the artery, although under the vein, was not under the bronchium; but it was applied to the latter behind. In a second subject, the artery on both sides was anterior, the bronchium posterior, the vein intermediate; and the artery was superior with relation to the bronchium, the vein inferior. In a third subject, which I examined carefully only on one side, both the vein and artery were above the bronchium at the upper part of the lung; but at the lower part the vein was under the bronchium, the artery on a level with it: again, in the middle, both the vein and artery were level with the bronchium; but the vein was in front, the artery behind, and the bronchium in the middle. *(Ibid.,* Anim. 30.) Both the branches of the first bronchia, all the way to the lungs, are made up of imperfect rings, in the same manner as [the trachea]. *(Ibid.,* Anim. 31.) I have myself observed that a considerable space is left between the parietes of the chest and the lungs in inspiration, and much more in expiration. . . . Although I have blown into the bronchia, and persevered until a great quantity of air was sent in, yet I have never been able to observe that the interstices were dilated, but on the contrary, that by reason of the distention of the lobules, they were compressed and much diminished. But when air was sent into one of the interstices through an artificial opening, both it and many of the adjoining interstices were distended. Again, when a knife was passed

through the middle of the interstices, so as to divide the lobules from each other, and the flame of a taper was held to the divided parts, and the air driven frequently and forcibly through the bronchium, (to shew whether the flame by its agitation would afford evidence of the air passing into the cavities of the interstices,) in this case, although we always saw the lobules dilated, in no instance was the flame ever so slightly disturbed or shaken." *(Ibid.,* Anim. 33.)

391. Swammerdam. "The ramifications of the trachea constitute the principal part of the louse; they exist in immense numbers in the head, breast, belly, and legs, and even in the antennæ or horns: . . . these are the white vessels that are seen through the transparent body in different parts. What makes them shine through the skin, is, that they are of the color of silver, or bright mother-of-pearl; and they constantly keep this color, even after they are removed from the body, for their structure is such that they never collapse. . . . One part of them is composed of rings, which resemble the cartilages of the trachea in man. It appears very distinctly by the microscope, that these rings often bend themselves round, so as to form a cavity and open pipe; . . . they are also much curled and twisted, as it were in a serpentine manner, and seem here and there to be interrupted. Where the trachea divides into branches, these rings are largest. . . . The orifices of the fourteen pulmonary pipes are seen in the outer skin; one on either side of the breast, and six on either side on the margins of the abdomen. . . . These orifices are the respiratory points. . . . In the belly these points are somewhat prominent, like little papillæ, and in their circumference seem to have a slight rim or border. From every respiratory point there runs a branch of the trachea, which soon anastomoses with some other branch proceeding from another point, and both close into one canal; . . . so that the air which is drawn into the body by one respiratory point, may be conveyed through the whole. . . . The pulmonary pipes may not only be discovered in the head, breast, and abdomen, but they extend also into the intestines, the ovary, the spinal marrow, the brain, and, in fine, into all the internal parts of the body. All these things I have distinctly seen. *(Biblia Naturæ,* p. 71, 72, 73; and tab. i., fig. 4, 7, 8.)

"The verge or border that surrounds the whole body of the covered snail . . . is connected very closely to the margin of the shell, both internally and externally. It is provided with a great number of muscles; . . . and hence its true figure cannot be determined, for it is continually contracting, expanding, and changing shape. Where it is connected to the upper part of the snail's body, it exhibits two singular incisions, like two little tongues; and underneath the right side of the

belly it has a remarkable aperture, which serves to take in air: and another besides, through which the fæces are voided. . . . The heart and its veins are continually refreshed and refrigerated by the air, which the snail impels thither through the aperture of its verge: for as the snail rolls its body out of the shell, so in proportion it drives the air into the cavity of its verge; and again, in proportion as it draws its body back, in the same proportion it expresses the air from thence. . . When the snail, after having crept out of the shell, is put into water, the air which it has drawn into the cavity of the verge makes it swim on the surface; but when it is again within its stony skin, and the cavity of the verge is closed or compressed, it then sinks to the bottom if placed in water. But if the snail, as it lies in the water, creeps again from its covering, the cavity of the verge is immediately filled by the water rushing into it, which then does the business of the air, that under ordinary circumstances would have been impelled thither. Hence it happens, that by a new kind of respiration, this water moves sometimes within, and sometimes without the shell, according as the snail rolls its body out or draws it inwards." *(Ibid.,* p. 111, 112, 113; tab. iv., fig. 1, *e. g.*; tab. v., fig. 4, 5, *b.*) The author also makes mention of "various cavities in which the air is moved," near the vena cava and the heart. *(Ibid.,* p. 118.)

"In the hemerobios or ephemerus, the trachea, pulmonary pipe or aspera arteria . . . consists of two principal trunks, which are disposed on each side of the body in a serpentine manner, and distributed throughout the breast, head, belly, legs, and wings. . . . These tubes consist of innumerable little rigid and curled parts, like twisted or spiral rings, so closely connected to each other by means of delicate membranes, that they can easily retain and convey the air. . . . When the silk-worm casts its skin, some hundreds of pulmonary pipes in the inside of its body cast their tender little skins, which are entirely composed of such twisted rings. The color of these pulmonary pipes is like that of mother-of-pearl, but somewhat inclining to gray. . . . They are distributed in the head towards the nerves and brain; in the thorax, to the muscles of the feet and wings; in the abdomen, to the obliquely ascending and straight muscles; also to the spinal marrow; to the lactes or seminal vesicles of the male; to the hairy branchiæ or gills; to the stomach, the intestines, the skin, and the coat of the wings; to the ovary and the coat covering the ovary; to the eggs themselves; and even to the heart. . . . The nearer these two tubes approach to the head, the smaller they become. . . . Their little apertures or entrances lie underneath in the side of the breast. . . . In order to discover whether there is really any air in these vessels, they must be put into a little drop of

water, and pressed with the point of a needle, when the enclosed air will immediately shew itself. When these insects are dissected under water, and some of the pulmonary pipes cut off, the latter immediately rise to the surface. . . . A great number of them are distributed to the tremulous branchiæ or gills. (*Ibid.*, p. 249, 250, 251, 252; tab. xiv., fig. 1.)

"In the rhinoceros beetle, the ten respiratory points (five of which lie on each side of the body) are covered by the cases or sheaths of the wings, except when the beetle is flying, at which time the sheaths of the wings are lifted up, and remain elevated without motion; so that these points are then uncovered; apparently in order that the beetle may the more freely draw breath, fill its pneumatic bladders with air, and thus make itself lighter for flying. Besides the above, there are also three other respiratory points on each side of the body. . . . In the worm the pulmonary pipes resemble branches of trees without leaves; in the beetle they resemble a tree expanding with leafy branches; . . . with this difference, however, that the leaves of trees have a plane and smooth surface, whereas these bladders or vesicles in the beetle are hollow, turgid, expanded to an elliptical figure, and somewhat swelled or blown up by the force of the air impelled into them. . . . From the apices of these vesicles . . . other pipes break out laterally, which after again dilating into vesicles, in their turn form air branches, vesicles, and pipes. . . . It is likewise observed that many tubes occasionally arise from one vesicle. . . . The little branches of the trachea consist of contorted and spiral parts, like rings of silver wire twisted round a cylinder. The pipes consist of a mixed horny and bony pellucid matter. They are likewise lined on the inside by very delicate membranes; but where they dilate into vesicles, they are entirely membranous, and when viewed with a powerful microscope, they are observed to be planted over with innumerable minute bullulæ. (*Ibid.*, p. 335, 338, 339, 340; tab. xxix., fig. 5, 9, 10; tab. xxx., fig. 1.)

"The structure of the wings of the gnat is exceedingly beautiful; they consist partly of pulmonary pipes, and partly of delicate and transparent membranes. They are of an oblong form, and of a glassy color, but darkened or shaded by a great number of scaly, rhomboidal feathers. The pulmonary pipes run through them like so many veins and nerves. The feathers are fixed upon the pipes; and this construction prevails throughout the wings. (*Ibid.*, p. 359, 360, tab. xxxii., fig. 3.)

"The respiratory points of the bee-worm are twenty in number, ten on each side of the body. . . . The twenty pulmonary pipes arising from them are carried inwards into the body, and all communicate with

one another: a kind of little tube runs along from point to point, so that the anastomosis is propagated through the whole body. They all consist as it were of curled rings, twisted together in the closest manner, and connected by the finest filaments and membranes. . . . Where they divide into branches, they are joined together by means of the lengthening, abbreviating, and curving of the rings. . . . The brain, the nerves, and even the eyes, as well as the whole body, are furnished with them. *(Ibid.,* p. 410, 411; tab. xxiv., fig. 1, 2, 3.)

"The lungs of the common bee are two white and transparent vesicles, formed by the running together and dilatation of the pulmonary pipes; but they are entirely membranous, and collapse when the air is out of them; which is by no means the case with the tubes that proceed from them, inasmuch as the latter, consisting of rings curled round, remain always open. The lungs, formed in the manner abovementioned, terminate again in little annular tubes; these enlarge again into vesicles, and the vesicles in their turn contract into little tubes. . . . The lungs, by the intervention of the little tubes which they send out, communicate everywhere with themselves by mutual anastomoses. *(Ibid.,* p. 452, 453; tab. xvii., fig. 9.)

"In the caterpillar of the day-butterfly, the pulmonary pipes arise from three remarkable pairs of branches, which are seen on each side in the breast, belly, and tail of the caterpillar. They communicate with each other at every one of the respiratory points; . . . and thence spread themselves all over the body: so that there is no part thereof, not even its horny substance, that is not furnished with them." *(Ibid.,* p. 577.) Respecting the pulmonary pipes of the worm from which the gad-fly is produced, see *Ibid.*, p. 662, 663; tab. xl., fig. 1, 2: and of the acarus or mite, *Ibid.*, p. 697, 698; tab. xliii., fig. 2.

The lungs of the frog.—"Malpighi, Needham and others affirm, that the frog has visible lungs, and performs respiration. . . . They have also observed branchiæ or gills in fish, answering the purpose of lungs, and all the blood in the body circulating through them. . . . Toads, water newts, lizards, chameleons, tortoises, serpents, &c., are provided with membranous lungs. . . . The frog has no lacteal veins; and for that reason, its chyle must necessarily enter its numberless mesaraic veins, and be thus conveyed through the vena portæ to the liver. . . . The heart of the frog, like the hearts of fish, has only one ventricle, with one artery issuing from it, . . . which soon divides into two trunks. . . . Each of these trunks is something like a subclavian, and immediately divides into three principal branches. The first of these, which is the least, goes on each side to the lungs; . . . and in its course divides commonly into three little branches, and then pro-

ceeding outwards to the coat that surrounds the lungs, forms thereon a truly wonderful vascular network. From thence the branches also pass down by very small shoots into the irregular internal vesicles of the lungs, among which the pulmonary vein is diffused, and with the latter they form a remarkable anastomosis. . . . Out of the pulmonary arteries likewise proceed two small branches on each side, which turn upwards, and are distributed through the parts of the mouth. . . . Only a small part of the blood circulates through the lungs. . . . The arterial vein is wanting in the lungs of the frog; [this is also the case in fish, but in them the blood is propelled to the branchiæ.] (*Ibid.*, p. 830—834; tab. xlix., fig. 2.) It is remarkable that living worms are almost always found in the lungs of frogs: I have sometimes met with as many as six in one frog. These worms, on their fore part, are very similar to common earth-worms, but behind they are somewhat thicker; they generally lie folded up within the lungs. . . . Their color is a yellowish white, excepting towards the tail, where they are black. . . . They have their mouths constantly fixed to the internal membranes of the lungs, from which they suck the blood. On separating them cautiously, we may observe a little opening that they have made, and blood discharging from it. . . . Another species of worms is also found in the lungs of frogs. These worms are like fine bristles, coil themselves up, and have sharp heads and tails. . . . I convinced myself that a great number of particles which I saw were no other than so many roundish oblong eggs, in which also there was a very discernible motion. In every one of these eggs I found a minute but perfect worm; lying folded up like a young serpent in its egg. These little worms, when extracted from the eggs, moved exactly in the same manner as the parent worms. This was an undeniable proof that the creature was both oviparous and viviparous, and propagated its species in the most surprising manner." (*Ibid.*, p. 803, 804.)

392. THE organic forms or living structures, determined by their essentials, that is to say, by the vessels and fibres, and bounded and covered in by their common bonds or sheaths, require to be excited at intervals to their natural exercitation and play of motion, in order that their powers may become active forces, that the inherent nature of each may declare itself, that their labors may be prosperous, and that they may return perennially to their primitive state, and thus perpetuate life (*a*). This play of motion consists in the alternate expansion

(*a*) A distinct idea should be formed, and a distinct conception gained, of the sources of motion in the organic body, for by this means we may form a distinct idea of the consecutive order, and of the subordination, of the causes of all effects. There are three general sources of motion, namely, the animation of the brain, the systole and diastole of the heart, and the respiration of the lungs: any other sources of motion are merely derivations from these springs, and as it were parts of a whole. With respect to the systole and diastole of the heart and arteries, they are intended simply to produce the organic forms, and to maintain them in integrity afterwards; for the blood-vessels are the essential determinations that mark out or delineate the forms or organs. But these systolic and diastolic motions are of no further import; they excite the works determined by them to no action. Hence a source of motion is wanted, that will act generally upon the organ formed by the blood-vessels, and at the same time particularly upon all its links or particulars, and rouse them into operation. The motions of the heart and arteries merely communicate potency to the organic structures, but are incompetent to produce a single action. To ensure the latter effect, the brains enter into association with the lungs, which flowing with their motion into the universal organic ma-

or swelling of the whole and all its parts: it is termed respiration and animation in living subjects; oscillation, vibration, and trembling, in inanimate subjects; and modification, in the atmospheric world; and the latter of these coincide with the former: and it is as well common, or a condition of the whole, as singular, or a condition of the parts; so that it receives its name from its subjects, offices and internal relations. Precisely as the least forms oscillate, vibrate, and perform modification, so also do the larger and the largest (*b*); so for instance, does

chine, flow also into each of its structures, and all their parts, as was pointed out, and confirmed by anatomical experience, throughout Part I. of this Work, and specifically in the Chapter on the Peritonæum, where we shewed, that all the viscera of the peritonæum are maintained in the exercise of their functions, under the alternate vicissitudes of the respiration, by means of an influx through the diaphragm and the peritonæum. Wherever in the world or in the earth's kingdoms, there are substances endowed with active power and force, and therefore intended for performing certain functions and generating certain effects, there these substances likewise are constantly excited, by extraneous causes, to a species of respiration or animation, and this, both in general and in particular. Apart from such incentives or excitations, the substances would be bare forms, or determinations of essentials, subject to collapse in a few moments, and to be numbered among forceless and dead things. The same remark applies to the world's atmospheres; were they not to be roused, generally and individually, into something like an animatory or respiratory motion, they would instantly lose their vital principle, and change into heavy and sluggish things: also to the kingdoms of the earth,—to the vegetable and even to the mineral kingdom. All things derive their power of action from this motion; all things in the animal body derive from it their ultimate life. The determination of the essentials,—the circulation of the essences,—does not give life in act, but only existence and life in potency. I am now, however, speaking of the ultimate or corporeal life, and not of the intimate or spiritual life: into the latter description of life I intend to inquire in another place.

(*b*) Oscillations, vibrations and modifications are nothing more than reciprocal and alternate expansions and constrictions of a mass or volume; of the parts in a mass or volume; or of the individua or singulars in the parts; difference in quantity,—more or less,—does not destroy the essence of the thing; although diversities of the kind,

the universal machine of the organic body. The production of this effect, is the end of those pneumonic bellows, the lungs, the alternate respirations of which, call all things into activity, and infuse into them new and living powers of action. The breath of life that was breathed into the nostrils of the first parent of the human race, was no other than the respiratory breath of the lungs;* for it is this that opens the scene of bodily life, as well as in a certain image represents the higher life (*c*).

inasmuch as they affect, present themselves and operate differently, must be expressed by different words or enunciative formulæ. But whether the elephant or the minutest insect swells and subsides alternately by virtue of the pneumonic breath, still the effect continues to be respiration or breathing, although in the insect it rather resembles minute vibrations or tremblings. If any little part of a viscus opens and collapses synchronously with the lungs, the action is nevertheless respiration, although it may seem rather to approach to the characteristics of modification. So likewise in the atmospheres of the world;—if they also in general, or in their greatest volume, or in the least volume, that is, in their unity, alternately contract, and then regain their pristine dimension, then of course there is no reason why these actions should not be likened to the modes of respiration, for in both cases there is expansion and constriction, and in both cases the subjects are roused to perform operations corresponding to their form. In fact, if we desire to learn the nature of modifications by means of actual sensation, or *a posteriori*, that is, by the analytic way, we need do no more than examine and consider the lungs.

(*c*) The breath of life that was breathed into Adam's nostrils, means nothing more than respiration, or the opening of the lungs. This case is similar to that of new-born infants, whose lungs are opened, in order to enable them to enter upon the career of bodily life, and to commence the motive and sensual life, and thus to learn to live in the spirit, at the same time that they learn to live in the body; as will be proved in another place: meanwhile, see *Genesis* ii. 7; vi. 17; vii. 15, 22. *Exodus* xv. 8, 10. 2 *Samuel* xxii. 16. *Psalm* civ. 3; &c. In these passages the atmosphere or wind is used as synonymous with the breath of life.* The same conclusion may be drawn from the

* Swedenborg took a further view of this subject in his theological writings. See his *Arcana Cœlestia*, and *Angelic Wisdom concerning the Divine Love and Divine Wisdom*.—(*Tr.*)

393. It is perfectly manifest that the most general use of the lungs consists in respiration; but we must go farther than this, and enquire what respiration has to do with life; nor must we rest here, but must push the matter still onwards into ulterior purposes, investigating the use of use: finally, we must discover what is the last use of the series, or the use that brings up the rear, which last use, like a gem in a diadem, or in the circle of a crown, will also become the first use, and will lead the van: for there is a perpetual chain of uses, as of effects and causes; for every cause and every effect involves a use.

394. The office imposed upon the lungs by their nature and structure, consists in admitting the contiguous air, through the larynx, the trachea, the bronchia, and the bronchial ramifications, into the vesicles of the lobules, and in immediately driving it back again through the same line of passages: thus by inflating their bags at intervals, the lungs expand and contract; they draw breath or take in air; in a word, breathe or respire. *Inspiration* is brought about by the force of the incumbent air, when opportunity is allowed it of passing into the given apertures. The force of the air is ascertained by multiplying the height of its column, and the consequent gravity, with the area of the given orifice; and according thereto, it presses equally against the sides in every direction (*d*). Proportioned to this is

course of the inspiration, namely, through the nares, and from the manner in which it is said to have taken place, namely, by inbreathing. And it will become still more evident, after we shall have shewn what the soul is, and what the body, and that the soul weaves the first and last threads of the body; and thus that from the first moment of life, inasmuch as it is the universal substance or essence, it is universally present, potent, active, conscious and provident, in its microcosm. See Part I., n. 313, the Chapter on the Peritonæum.

(*d*) The experiments of Pascal especially, as well as of many later writers, have satisfactorily demonstrated, that air, like water, presses upon a given area with a force proportioned to the height of its column: hence that it is found to press with different degrees of force upon the mercury of the barometer, according as the experiment is made upon lofty mountains and in high buildings, in deep mines, or under the exhausted receiver of an air-pump: and the same remark applies to water and other fluids. But in measuring the gravity of the air, one

its effort or endeavor; and furthermore, its actual power, as soon as it obtains the opportunity of rushing into the void spaces through the given orifice. By this force and gravity, then, the air opens all the bronchial locks that it comes against, separates the parietes, smooths out the corrugated passages, extends

difference necessarily occurs, namely, that the air itself may be of varying density or rarity, consequently, of varying gravity or levity; for being elastic, it will allow of being compressed considerably, as well as of being expanded considerably, with respect to volume or space: and thus the same height of column may produce a different result of gravity; as in the different regions and climates of the globe. These differences are likewise observed between northern countries, and places lying under the meridian sun. But the breadth of the column is measured by the area upon which it presses, which, multiplied by the altitude, (that is to say, by the mean altitude, which corresponds to the levity of the expanded air in the higher region, and to the density of the compressed air in the lower region,) gives the real amount of active force, in a word, the gravity, with which the air acts upon the given object. The aërial atmosphere has also another known property; for the air, proportionably to the increased and acquired power of action of the incumbent column, weighs equally, not only upon the area lying perpendicularly under it, but also upon other areas, whether oblique or looking directly downwards, so that it presses with equal force, downwards, upwards and obliquely: which is the reason why an inflated bladder forms a globular sphere; and why the action of the air is determined in like manner, in every direction, upon drops of water, bubbles of oil, and globules of quicksilver; consequently also upon the bronchial branches, upon all points of their surfaces, and forwards towards the vesicles, and in the vesicles to all points of their concave circumferences: whence the forms of the vesicles when expanded, resemble spheres, grapes, or pears, and the lobules, bunches of grapes. And hence we may infer, that the air not only operates by virtue of its elasticity, but also presses by its gravity; which shews that it is a partly terrestrial and partly celestial atmosphere: (that is to say, if the term Celestial be applied to the higher and more perfect atmospheres, according to the usual mode of speaking adopted in the Holy Scriptures.) It is evident from the passage of the air into the lungs, that its action overcomes the proper reaction of the lungs; for the pulmonary pipes contract naturally to the smallest possible diameter or dimension, as plainly shewn in the embryonic state, as well as after death, when the lungs are collapsed.

the very foldings of the interstices (*e*), and finally expands the vesicles,—empty, collapsed, and united to each other in the way of pyramids by plane surfaces,—into aërial bullæ and pyriform spheres, and thus raises a number of them into a distinct lobule (*f*). At the same time the intercostal muscles, the

(*e*) It has just been shewn, that the natural state of the bronchial pipes or lungs, is a state of contraction, in which state the cartilaginous circles or squamous segments in the bronchia, approach nearer to each other; and even the ligamentary tunic which exists in the place of the cartilages in the ramifications, runs up together, and perhaps, like the blood-vessels, forms folds or gathers: shewing that these air-passages are folded together during expiration, but are smoothed or spread out during inspiration or extension. "In drawing out any portion of the bronchia by the two ends," says Winslow, "these segments are parted, and the whole canal is increased in length; but it contracts again by means of its elastic membrane as soon as the force is taken off. When we open lengthwise any portion of the pulmonary artery and vein, . . . we meet with a great number of transverse rugæ, which are obliterated when these vessels are elongated" (n. 387). The same thing occurs in the interstices, that is to say, in the cells or cellular substance that surrounds the bronchial ramifications; for when the bronchia are in the state of contraction, these cellular spaces approach each other, and their foldings compress each other and adhere together; but when the tubules are extended, the interstices are necessarily unfolded lengthwise. "These three vessels," says Winslow, "[the bronchia and the pulmonary arteries and veins] lie in a sort of cellular sheath, which accompanies all their ramifications, and is a continuation of the interlobular cells, or cellular substance in the interstices of the lobules. The pellicles which compose it are, however, disposed there in a more regular manner, and more longitudinally, than in other places, and thereby appear to form a true sheath." (*Ibid.*)

(*f*) The vesicles or last bronchial cells, that receive and throw out the air, and are in a manner the hippodromes or goals whither the air runs forth, and whence it runs back, after having performed its little circuits and turnings, in their contracted or emptied state are rather angular and pyramidal, than globose or uvular, and are in contact with each other by flat surfaces, and not by mere points. See Malpighi, *De Pulmonibus*, tab. i., fig. 3. "The lobules," says Winslow, "are always angular, oblong, broad, straight, &c. . . . When we inflate the lungs, the bronchial cells nearest their outer surface appear like small

triangulares sterni, the muscles of the diaphragm, and several others that are supplied by the trunks and branches of the twelve dorsal nerves, contract, and raise the ribs, extrude the vertebræ, expand the diaphragm, and thus enlarge the thorax (*g*):

masses of round vesicles; and from this appearance they have all got the name of vesicles, though they are all angular, except those which I have now mentioned." *(Ibid.)* And Boerhaave remarks, "The vesicles must be extended by the air, from a flat and compressed figure to one more spherical and capacious; and hence the spaces between the cartilaginous segments, branches or bronchia, and vesicles of the lungs, must be increased." *(Inst. Med.,* n. 197.)

(*g*) We may infer what muscles are peculiarly employed in the respiration of the lungs,—I am not now speaking of the varied respiration that takes place during the voluntary and natural actions of the body, when the most extensive coöperation exists among the muscles of the thorax and abdomen, but of ordinary respiration, such as exists in sleep, and indeed in the waking state, when the animal mind is at rest, and the body in no way excited to action,—we may infer, I say, what muscles are particularly employed in this case, in some measure, though not clearly, from the connexion of the muscles with the ribs, the diaphragm, the sternum, and the vertebræ; and in some measure from reflecting upon the motions of the chest and lower belly, during the continuance of the above normal respiration. But in my opinion, the surest way of recognizing the genuine respiratory muscles, and distinguishing them from those other muscles that merely lend a helping hand during extraordinary actions, will be, by assuming as our principle the twelve costal or dorsal nerves, and their influx into the muscles. For these nerves proceed distinctly from the dorsal region of the spinal marrow, and running out parallel to the ribs, are inserted into all the muscles that in any degree contribute to enlarge the chest. Now the enlargement of the chest, and the consequent elevation of the ribs,—even in a measure, of the false ribs,—and of the sternum and the diaphragm, is the only thing that allows the lungs to respire. Thus every time the spinal marrow expands and contracts, together with the cerebellum and the cerebrum, it inspires all its nerves, and rouses them to act upon the muscles, and the muscles to act upon the ribs and the diaphragm; which is the reason why the animation of the brains and the respiration of the lungs are exactly coincident in their movements. In order, then, that we may learn by the nerves, to distinguish the genuine respiratory muscles, let us consult Vieussens, *Neurographia*

by virtue of which circumstances, there is nothing, from the inmost parts to the outmost, to resist the advance of the air, and the intumescence of the lungs. *Expiration*, on the other hand, is brought about by a general contractile effort on the part of all the internal constituents of both the lungs, that is to say, of the fibres, nervous, ligamentary, motive and tendinous, and of the vessels that support and construct the ramifications of the bronchia, or their cartilaginous pieces, delicate circles, and membranous integuments (*h*). Simultaneously with this

Universalis, tab. xxvii., where he graphically represents the twelve dorsal nerves, running parallel with the ribs; and we may see that from them and their anastomoses and branches, there evidently proceed various nerves, which are simultaneously excited to action, not only by the spinal marrow as an internal cause, but also by the elevation of the ribs as an external cause: for all these nerves pass into the intercostal muscles, however the latter are distinguished by different names, as super-costales, inter-costales, and intra-costales; also into the triangulares sterni: and their ramifications, reflected from the ribs, and slanting in their course, enter several of the muscles of the thorax; thus a branch of the second dorsal nerve, united with a branch of the thoracic ganglioform plexus of the intercostal nerve, supplies the subclavius and serratus minor anticus [pectoralis minor]. (*Tab. cit.*, E); besides which, a nerve is reflected from the brachial nerves to the diaphragmatic nerve (*Op. cit.*, tab. xxiv., T); and branches pass from all the other [dorsal] nerves, to the pectoralis major, serratus major [serratus magnus], serratus posticus superior, serratus posticus inferior, and cervicalis descendens; and to the pleura and the mediastinum: and their ulterior and lower ramifications supply the longissimus dorsi, the sacro-lumbalis, and the integuments and muscles of the abdomen. By considering the influx of all these nerves, we are enabled to conclude respecting the way in which the muscles coöperate to produce the same effect, whether generally or particularly, nearly or remotely; and respecting the form of action which they produce by their simultaneous operation, according to the way in which the nerves pass into them, when ordinary respiration is going on. But it would require a volume to do justice to this subject.

(*h*) According to what was stated above in note (*d*), the pulmonary pipes contract spontaneously, and constantly tend to assume the smallest possible dimension; and if this be true of the pipes, of course it is equally true of all the causes,—that is, of all the filaments,—that con-

effort, the before-mentioned muscles relax, the ribs are retracted into their natural situation, the diaphragm is relaxed and hollowed, the concave surfaces of the lungs adapt themselves to the hollow, and the thorax is contracted in its whole circumference; thus there is nothing but drives the retreating air, and applies itself to the subsiding lung (i). Hence the in-

stitute the pipes: the contraction of the pipes is only an effect of the contraction of these filaments; consequently of the contraction of the *nerves*, that spread in all directions through the lobes of the lungs, issuing from the plexus formed by the par vagum and intercostal nerve, and climb up and twine round their blood-vessels and air-pipes in various ways. See Verheyen, *Corp. Hum. Anat.*, tract. vii., cap. v., tab. xl., fig. 1: and Willis, *Pharmac. Ration.*, pars II., sec. I., shewing these nerves [separated into fibrillæ, spread out and] greatly magnified. The contraction of the pulmonary pipes is also caused by the contraction of the *sinewy fibres* represented by Morgagni (*Advers. Anat.* i., tab. 1), and which run longitudinally in the bronchia and their ramifications, partaking somewhat of the nature of muscular, somewhat of the nature of tendinous fibres. Respecting these, Winslow says, "As the bronchia penetrate into the substance of the lungs, they gradually lose their cartilages; but the muscular lines or columns of Morgagni appear as much, and sometimes more, than before" (n. 387). The above contraction also involves that of the cartilaginous segments; "When we examine a lung without inflation," says Winslow, "we find that the cartilaginous segments of the bronchia lie so near as to be implicated in each other." *(Ibid.)* And equally that of the membranes which succeed the cartilaginous segments and plates in the ramifications.

(*i*) The proper action or contraction of the lungs is not of itself sufficient to countervail the incumbency and pressure of the air; it requires to be assisted by a general auxiliary power; namely, the return of the ribs, and the natural compression of the thorax. When the action of the muscles intermits, the ribs return spontaneously into their places; for they and their cartilaginous extremities have tendons and aponeurotic membranes connected to them, which act as antagonists to the costal muscles, and diminish the pectoral space by themselves contracting and by drawing down the ribs. Thus the internal natural contraction of the lungs, must concur with the external natural contraction, before the lungs can countervail the pressure of the air; and when this concurrence is effected, then the expulsion of the latter takes place. Furthermore, all the ribs are in some measure implicated with the

ternal forces of the lungs, which are natural (*k*), and the external forces, which in the day time, and during the waking state, are voluntary (*l*), concur to each alternate movement of the respiration. The internal forces or parts yield to the pressure

border of the diaphragm, and its peritoneal covering, and when these parts are relaxed, the tendons, muscles, coats, and other powers, likewise are enabled to assist in drawing down the costal levers into their natural position and situation.

(*k*) For the branches of the plexus formed by the par vagum and intercostal nerve, proceed from the cerebellum as their natal soil, as we have often observed above, and shall demonstrate in the proper place; hence all the acts that proceed from these nerves, are natural, because acts of the cerebellum. "The lungs," says Winslow, "have a great many nerves distributed through them, by filaments which accompany the ramifications of the bronchia and blood-vessels, and are spread on the cells, coats, and all the membranous parts of the lungs. The middle and great sympathetic nerves, commonly called the nerves of the eighth pair, and the intercostals, form behind each lung a particular intertexture, called the *pulmonary* plexus, from which nervous filaments go out to communicate with the cardiac and stomachic plexuses." (*Ibid.*) Now if the very filaments of the nerves are in a state of contraction, of course the vessels, sinewy fibres [muscular lines of Morgagni], and membranes, in short, the whole of the tubular and vesicular apparatus of the lungs, must be in a similar state; for the latter are composed of and constructed by the former. The nerves appear to have received their power of contraction during embryonic life, when the lungs, from their very formation, were in a state of collapse.

(*l*) All the nerves, with the exception of the par vagum and the intercostal nerve, and perhaps with the exception also of those sent by the restiform process of the cerebellum towards the genital members, are subject to the will of the cerebrum; such is the case with the twelve costal and the other nerves that descend from the medulla oblongata and medulla spinalis. This, however, as we all know, applies only to the waking state; for during sleep the same nerves act under the auspices and government of nature. The cerebrum rules in the day-time, and excites itself at will to general and particular animations, and with it the cerebellum, medulla oblongata and medulla spinalis. The cerebellum, on the other hand, takes up the reins at night, and obliges the cerebrum itself, and the two medullæ, to follow its own reciprocal acts of animation. That the government is thus alternated

of the air, while the external contract, raise their levers, and provide the requisite space; and *vice versa*. Thus the contraction of the voluntary muscles, united with the action of the atmosphere, gives the air the power of inflating the lungs, and of overcoming nature; and the contractile action of the lungs, in conjunction with a similar action on the part of the levers of the thorax,—the will the meanwhile being in a state of repose,—gives nature the power of throwing out the encroaching Æolus; hence the province of the will is confined to admitting, and during good pleasure retaining, the aërial guest; but driving it out, is left to nature (*m*). The above circumstances clearly

and divided between the cerebrum and the cerebellum, that is, between the will and nature, will be shewn in the Parts on the Cerebrum and Cerebellum. The circumstance of our breathing with the lungs more deeply and fully during the night than during the day, arises not only from the energy of the cerebellum, (which is a small mass compared to the cerebrum, with the whole of its own medullary appendages, and those of the great stems proceeding from it,) but also from the state of the lungs in sleep; but in the day time, the lungs with the cerebrum being awake, are almost constantly half expanded, and their vesicles half open; as we shall have occasion to mention presently.

(*m*) It would appear at first sight that the will performs both parts, and governs expiration as well as inspiration, since under the premonition and direction of the will we have the power both of prolonging and letting-go the breath. But if we duly consider these vital actions, we shall discover enough to convince us that in ordinary respiration, inspiration alone belongs to the will, and not expiration. The contrary appearance arises from the fact, that the will can intermit its inspirations at pleasure, and as soon as ever it does this, nature takes up the matter, and completes the act; in short, draws down the ribs, sternum and diaphragm, into their natural position and situation. The same thing occurs in the cerebrum; the province of its will consists in expanding it, but to produce the opposite condition is the province of certain reagent ligaments and tendons, which complete the work. The only thing voluntary in the latter case is, that the cerebrum has the disposal and option of giving nature leave to act. Thus for example, when we raise the arms, legs, or feet, the will has the power not only of lifting them, but of keeping them lifted as long as it pleases; but when we let down the same parts, their descent is committed to nature; that is to say, to the tendons, the antagonist muscles, and the weight

shew the nature of the equilibrium that exists in ordinary respiration, between the gravitating powers of the circumambient atmosphere, and the singular or internal powers of the lungs in conjunction with the common or external powers of the thorax (*n*).

of the limb. So when we throw ourselves upon our couch, either on our backs or our faces, we bring ourselves into the proper centre of gravity, and then leave our descent to be effected by the weight of the body: the same rule applies to other cases. For the corporeal machine is constantly held together in its natural position and connexion, by a number of appliances, membranous, muscular, aponeurotic, tendinous, cartilaginous and osseous. All activity resulting from the will tends to disturb and break up this position and connexion; and hence nature is obliged to take the reins alternately from the will, so that every time she is thrust from her state by the acts of the will, she may be able to restore herself to herself. See below, n. 400. By taking account of these circumstances, we may infer the particular mixed action of the will and nature existing in ordinary respiration, and the primary cause of such mixed action; namely, that the will governs only the external muscles of the thorax, but not in the least degree the internal forces of the lungs, excepting by mediation from the external, through the common membrane and intervening ligament. Now as expanding the thorax is a voluntary matter, so, it is a voluntary matter that the gravity of the air overcomes the resistance of the bronchia and vesicles. Nevertheless, in extraordinary respiration, when the pulmonic breathing has to concur with voluntary actions, a different condition occurs, and in this case the will sometimes governs the expiratory equally with the inspiratory acts. See below, n. 401.

(*n*) Inspiration and expiration go on like the balancing movements of a pair of scales; which scales are the ribs, according to the elevation whereof, the resistance of the internal parts of the lungs is overcome by the pressure of the air. But the circumstance that living lungs are expanded more easily than dead lungs, or lungs removed from the body, —in fact, so much more easily that their expansion appears almost spontaneous,—is attributable not only to the arterial blood thrown in by the heart, and to the nervous fibres swollen with their spirit by the living brain; but also to the state of the bronchia and vesicles, during wakefulness, at which time they are half opened, and covered with a viscid fluid, which glues together many of the passages after death. Lastly, it is to be observed in this place, that the external coat of the

395. Not only do the lungs themselves respire, but they also cause the whole of the organic system to respire along with them; namely, both the middle region, in which they themselves are situated; the superior region, which is that of the head and the cerebrum; and the inferior region, or that of the abdomen; and in fact, even the appendages of the trunk,—the arms and hands, the legs and feet, down to the tips of the fingers in the one case, and to the ends of the toes in the other: so that there is not a corner in any province of the kingdom, whither the pulmonic breath does not penetrate with active power; and this, by the mediation and instrumentality of a number of general appliances,—for instance, of the mediasti-

lungs, which is continuous with the mediastinum, and by the [broad membranous] ligament (n. 387), with the pleura, coöperates and conspires with the vertebræ, the ribs, and the diaphragm, to produce the expansion and constriction of the lungs; this coat being relaxed in exact proportion as the pectoral space is enlarged, and *vice versa*. Thus there are two external forces, each in complete agreement with the other. This is the reason why a space is left between the lungs and the pleura even in living subjects; according to the observation of Morgagni. "I have myself observed," says he, "that a considerable space is left between the parietes of the chest and the lungs in inspiration, and much more in expiration" (n. 390). By means of the broad ligament just mentioned, the external surface of the lungs is connected to the pleura and to the diaphragm; consequently to the ribs, &c.; and accommodated exactly to their extension; and its action likewise is external, for it is concurrent with the most external action of the ribs and vertebræ. Respecting this ligament, Winslow says, "Under the root of each lung, that is, under that part formed by the subordinate trunk of the pulmonary artery, by the trunks of the pulmonary veins, and by the trunk of the bronchia, there is a pretty broad membranous ligament, which ties the posterior edge of each lung to the lateral parts of the vertebræ of the back, from that root all the way to the diaphragm" (n. 387). Something like this is the case in the liver and other members of the abdomen, which are bound down by the peritonæum through the intervention of ligaments, and produce a common coat in the form of a continuous web, by which those viscera are constrained extrinsically to yield compliance to the peritonæum; and especially is this the result in those instances where the ligament, as here in the lungs, is inserted in the spot where the substantials of the viscera enter.

num, the pleura, the diaphragm, the peritonæum, the ribs, and the vertebræ; speaking generally, by the mediation of the nerves, vessels, membranes, muscles, tendons, ligaments, cartilages, and bones; that is to say, of all the constituents that make up the compages of the whole. We shall clearly perceive this to be the case, if we consider the continuity, relation, and circling course of the above substances; nay, we may have sensible experience of it in our own persons, in the respective acts of sneezing, coughing, shouting, vociferating, evacuating the fæces, wrestling, and other similar operations, during which we distend the lungs and augment the breathing to the greatest degree; that is to say, provided we fix our mental vision attentively upon all the circumstances of the case. And again, the fact is brought completely home to our senses, and placed in clear light, in the simpler and less elaborate forms of the animal creation,—in worms, nymphs, caterpillars, butterflies, flies, and other little living machines of a similar kind; in which the pulmonic breath flows in, not as in animals of larger dimension, through so many mediations, and instrumental appliances, of ligaments, membranes and muscles, and through so many cartilaginous and osseous balances, but immediately, by air-vessels or bronchial pipes, dividing and ramifying in the form of fibres, through all the organic powers of the body; and this flowing in, by manifest coöperation expands their chain of uses (*o*).

(*o*) Respecting the wonderful ramification of the air-pipes in insects, see Swammerdam above, n. 391. In the caterpillar of the day-butterfly, these pipes communicate with each other, and spread all over the body, so that there is no part thereof, not even its horny substance, that is not furnished with them. In the gnat, they run through certain parts like so many veins and nerves. In the hemerobios or ephemerus, they are distributed in the head towards the nerves and brain; in the thorax, to the muscles of the feet and wings; in the abdomen, to the obliquely ascending and straight muscles; also to the spinal marrow; to the lactes or seminal vesicles of the male; to the hairy branchiæ or gills; to the stomach, the intestines, the skin, and the coat of the wings; to the ovary and the coat covering the ovary; to the eggs themselves; and even to the heart. In the louse, the pulmonary pipes may not only be discovered in the head, breast, and abdomen, but they extend also into the intestines, the ovary, the spinal marrow, the brain, and in fine,

396. The lungs not only effuse their moving breath or breathing motion into the general connecting media of the body, as the tunics, the muscles, and the septa,—and thence into the viscera enclosed thereby, as the stomach, the liver, the mesentery, the pancreas, the spleen, the kidneys, the bladder, the testicles, the vesiculæ seminales, the uterus, the ovaries, and the rest; but they also infuse it into the distinct particular congeries and simple forms of those viscera, that is to say, into their lobules, glands and follicles, down to the very intimate recesses of each: and thus the lungs excite them, every one, in their general form as well as in all their parts, to operate in accordance to their nature and structure, inspiring force into potency, and thereby giving birth to natural effects or actions (*p*). Thus respiration calls forth the intimate lives of the determinations,* into actions, or into their ultimate lives; so that the

into all the internal parts of the body, &c. Respecting the distribution of the pulmonary pipes in the worm from which the gad-fly is produced, see Swammerdam, *Biblia Naturæ*, p. 662, 663. In the acarus, *Ibid.*, p. 697, 698. In the covered snail, the pulmonary inspiration and expiration concur to all the vital motions, although by very different means to the above: see *Ibid.*, p. 111, 112, 113.

(*p*) In Part I., where we investigated the Viscera of the Abdomen, the reader will find it constantly asserted, that the natural and vital motions of those viscera are exactly synchronous with the spiratory winnowings of the lungs, but not with the rhythmical movements or pulsations of the arteries and heart; for the latter cannot expand or contract even so much as the smallest particle, or glandular initiament of any of the organs. Let the arterial filaments be ever so numerous in any little part, either glandular, papillary, or otherwise organic; or even let the whole texture be arterial, still, beyond the individual pulsations and movements of their capillaries, they have no power of contributing in any way to the expansion and constriction of the corpuscule generally: and I will go so far as to assert, that excepting they be in muscular fibres, they can nether lift nor compress any surface a single hair's-breadth beyond its plane or horizontal level; still less constitute a source of motion that will infuse activity into an entire part. It is one thing for a part to vibrate superficially, and another thing for it to swell and suffer contraction throughout its whole dimension, cavity

* See the definition of determinations, n. 382, note (*f*).—(*Tr.*).

lungs are the very gymnasia of the exercises, effects and uses and substance. From these considerations we may begin to discern what the beating of the arteries and the breathing of the lungs respectively contribute to the excitation of the works.* At first sight, however, it would appear, that before the opening of the pulmonary bellows, that is to say, before birth, every operation must have arisen from the sanguineous pulse. But if we consider the matter more narrowly, we shall find that even during this time, the arterial blood contributed very slightly to initiate the operation of the viscera; in fact that it did no more than flow into the motive fibres according to the alternate actions of the heart, and thus constantly and at stated intervals, expanded and constricted those fibres, or the muscles made up of them. But this is only an effect arising from the pulsation or circulation of the blood, and not a cause. The cause is referable to the nervous fibres, and by consequence to the general action of the cerebrum and cerebellum upon the motive fibres of the body, and their influxion into the same. Such is the cause of the reciprocation at this time, as well as of the operation of certain viscera in the primeval state. And since after birth the animation of the brain is coincident with the respiration of the lungs, therefore the same manner of cause continues still, and the same cause of the effect; but with this distinction, that before birth the animation of the brain must have been coincident alternately with the diastole and systole of the heart, but not in the second scene of life, after the opening of the lungs. And hence it is that in the embryo, nothing whatever could be called into action, excepting rhythmically or synchronously with the cardiac movements, and consequently no particular action could be produced—no action separate from the general action. But we shall treat of these subjects in another place. Meanwhile, that the stomach institutes its peristaltic motions, and the intestines, their vermicular motions, consonantly with the pulmonic motions, was shewn in the Analyses of the Stomach and Intestines; and that the liver, the pancreas, the spleen, the kidneys, and many other organs devoted to the procreation and purification of the blood and serum, exhibit the same consonance with the lungs in their motions, was likewise shewn in Part I. of this Work: and this, not only with respect to their mass, but with respect to all their parts. For each several organ has bonds

* The term "works" *(operæ)* appears to be used by Swedenborg sometimes to signify the mechanism of parts, as we use it when we speak of the "works of a watch;" sometimes to signify the operations of such mechanism. At other times it seems to combine these meanings. *(Tr.)*

corresponding to the ends or intuitions of the soul (q). Hence the numerous ligaments and fræna put forth by the diaphragm

or ligaments, one or more, sent to it by the peritonæum, as well as by the diaphragm, and inserted particularly in its depressed or concave part, where the ingoing and outgoing vessels all meet; and this bond or ligament, by a process of circumvolution, not only produces the external coat of the organ, but putting forth little sheaths, penetrates all the way to its intimate follicles and simple structures; that is, to its principles. Such is the case in the liver, the spleen, the kidneys, and the other members. It was furthermore shewn, that the peritonæum cannot be animated and agitated by any motion but what it derives continuously from the lungs, by means of the diaphragm, the ribs, the vertebræ, the nerves, the muscles, &c. And again, that the lungs flow intimately with their motion into all these viscera, not only by the mediation of the diaphragm, the muscles and the ribs, but also by the mediation of the nerves, particularly of the great intercostal and the par vagum, which enter the intimate substances of these viscera, and construct the same.

(q) That the lungs call forth or excite both the lives of the body, the motive life as well as the sensitive, will be presented in the form of a conclusion presently (n. 404); and if they call forth the motive life and the sensitive life, of course they determine into action all the works that properly belong to the body. But in order to our living by nature, as we live in the mother's womb, there is no necessity for forces of this kind,—forces excitative of the motions of the body and the senses; for the soul, living as a spiritual being in the prior world, needs no information from the external senses, but is far more discerning than they, and in truth bestows upon the innermost senses, and infuses into them, whatever discernment they possess. Nevertheless, when the soul distributes her power, and transfers it, if we may use the expression, to a certain mind, that is meant to be instructed by the external senses, and one day to become a rational mind, then all the works of the posterior world require to be opened, and this, by means of the lungs, which conduct us upon the stage of this world's life. The life of the soul in the embryonic body is an order of forces and operations proceeding *a priori ad posteriora;* but the life of the body is an order of forces and operations proceeding *a posteriori ad priora;* thus altogether the inverse of the former; for the human rational mind discerns nothing whatever, (excepting the nature of harmonies,) but those things which have come from beneath, through the instrumentality of the senses. The soul merely gives it the faculty of thinking, and

and peritonæum, thrown over all the viscera, connected by continuity with their external coverings, and produced into capsules or little sheaths, that enswathe their several essential determinations,* proper vessels, blood-vessels and nerves, surround them with a fibrous tissue, affect them perpetually, and in fine penetrate to all their intimate organic principles, whether vesicular or glandular. This is most clearly seen in insects; in which the pulmonic breath pervades the occult recesses of all these viscera, and mounts into them, not by the above substantial bridges, and extrinsic reins, bonds and capsules, but by an uninterrupted machinery of air-pipes, and so assigns to each viscus its particular lung, and inspires it with its own pulmonic breath (*r*).

397. This pulmonico-atmospheric air or spirit penetrates not only into the organic works enclosed in the peritonæum, but it even invades the heart itself, the much venerated and worshiped co-regent with the lungs of this living world, and the illustrious partner of their bed. From it the lungs derive their corporeal life and soul, namely, all its blood and venous constituents, as well as its tunics, proper and common; for its præcordia or particular pleura, termed the pericardium, passes in the form of a cellular and fibrous sheath, round the bronchial ramifications, the arteries, veins and nerves, to the intimate follicular clusters of the lungs, and there, as in so many centres, meets the terminations of the trachea, and enters into close and intimate union with them (*s*). The lungs, in their turn, foster in their

determining the conclusions from its thoughts into acts, but never concurs more immediately to its knowledges and perceptions. Hence the inverse and analytic path which we enter by birth, is not laid down or accessible, until the lungs have opened the scene, or drawn up the curtains of our theatre.

(*r*) See above, note (*o*). In numerous insects, the pulmonary pipes not only run like vessels into the viscera, but here and there expand into fresh bladders, or lungs, and pass from these again, by other similar pipes, into the neighboring organs, and so on repeatedly. Respecting these cases, see Swammerdam, n. 391.

(*s*) On these particulars, see the Chapter on the Pericardium, and

* See the definition of essential determinations, n. 392, note (*a*).—(*Tr.*)

embrace this ruler of the kingdom, press him to their breasts (*t*), and reciprocate the act of love; for they likewise enter his pericardium with their common coat, by means of the mediastinum and the diaphragm; and they enter the sinus of his left auricle, with all their blood, venous constitution, marrow and life: nay, they even surround his great arteries and veins, the aorta and the vena cava, with the pleura, with the diaphragm, and finally with the peritonæum; and more than this, they enswathe his bifurcations, I mean, the ischiadic, spermatic, and many other vessels, with a similar covering (*u*). Thus the lungs extend their action to these parts, as well as to their head, the heart; so that wherever the heart penetrates by means of the arteries,—whithersoever it carries the circulatory motion,—thither also it brings with it the spirit of the lungs. The heart, by means of the arteries, diffuses the blood, or the corporeal soul, in all directions, while the lungs affuse the spirit of this world, the ultimate and corporeal spirit. Hence the ultimate or corporeal life is the result of the union of these two principles, the preliminary scene of its drama being opened and commenced by the lungs at birth, when we make our first entrance upon the theatre of this world's life.

398. The respiration of the lungs flows not only into the trunk of the body, but also into the head, and into its organs

the citation therein from Lancisi, n. 419. "A capsule or tunic," says Heister, ". . . continuous with the pericardium, . . . encases the vessels of the lungs, that is, the pulmonary artery and vein, and the bronchia, both outside the lungs and in their substance, in the same manner as the capsule of Glisson encases the vessels of the liver" (n. 385). This capsule, according to Winslow, is identical with the cellular tissue embracing the pulmonary vessels; see n. 387.

(*t*) Respecting the manner in which the lungs cover and invest the heart, see Winslow. *Ibid.*

(*u*) Whether the pleura, the diaphragm, the peritonæum, or the lungs themselves, encase the vessels of the heart, it will amount to the same thing; for the lungs act upon the enclosed viscera by the mediation of those coverings. Whatever is attributed to the cause must also be attributed to the cause of the cause. The last effect is produced by the first cause, through intermediate causes.

of motion and sensation (*x*); and in fact to the cerebrum, the very fountain of its motion, to which it rises in infinite streams, as it were in meanders and circles, and associates itself with the reciprocal respirations, or, as we term them, the animations of the cerebrum. Thus the lungs, and the brains with the medulla oblongata and spinalis, are synchronous in their respective animations and spirations (*y*); and this, in order that causes may act harmonically, and conspire in operation, with effects; things prior with things posterior; and the spirit of the soul

(*x*) This is evident from the actual effect, and from the connexion between the parts involved: from the *effect*, when the lungs are filled to the greatest degree, namely, in that the face and its organs swell and grow red: from the *connexion* between the lungs and the head, through the membranes, the muscles, the trachea and the larynx, &c.

(*y*) The animations, or elevations and constrictions, of the cerebrum and cerebellum, cannot fail to be synchronous with the respirations of the lungs: otherwise the lungs could not conspire to the same effects as the brains. Putting aside the arguments and inductions derivable from the anatomy and connexion of substances, this statement is confirmed by the subordinations and mediations of all the causes that enter and constitute each particular effect; as in the present case by the fact that the lungs concur in the most absolute manner to every action originating from and ordered by the brains. The complete concordance is perfectly manifest from all actions. Thus when the mind is thinking very intently, and breathing tacitly and slowly, then the lungs, elevated to a certain degree, appear in like manner to keep silence, and to send out and draw in the air almost imperceptibly, so as not to disturb the analyses of the rational mind by any motion on their part. On the other hand, when the mind is heated with passion, and the cerebrum acts tumultuously, and as it were swells and surges, then the lungs likewise boil up. The same is the case in all the other affections of the rational and animal minds. In the first Chapter in this Part, in treating of the Nose, we shewed that the cerebrum is excited to its animatory reciprocations by external causes, every time the odoriferous particles of the air strike and affect the fibres of the olfactory nerves, which are the organs of the sense of smell. Hence it is that the lungs communicate their respiratory actions so extensively, in short, to all points of the body; for whithersoever the fibres of the cerebrum and cerebellum, and their modifications, penetrate, thither also goes the breathing motion or action of the lungs. See n. 424, 425.

with the spirit of the body; and in order that there may be an influx and reflux of the one into the other. On these accounts, the pulmonic engines or bellows rise precisely at the same moments that the cerebrum inspires its costal, and the cerebellum its sympathetic nerves (z).

(z) It is a truth constantly presented to us as the result of all our analytic investigations, that every action of the cerebrum and cerebellum is determined through the fibres; and that the fibres cannot be determined into act, excepting by their beginnings or principles; in short, by the organs that are prefixed to those fibres. The latter must certainly be excited to motion by their principles, and commence and describe their motion in this way. It is absurd to suppose that any action can begin in the middle of a fibre, and not in its first terminus. If then it begin in the first organs, it must inevitably begin in the cortical glands, for the fibres commence, and are conceived and produced, in those glands, and the arterial vessels of the cerebrum terminate also in them. Hence if the principles of motion exist in them, according to all physical and philosophical laws, as mutually confirmed by and confirming each other, those principles must necessarily commence by a kind of active, living, or locomotive, reciprocal force, that is, by a kind of expansion and constriction, or systole and diastole, such as we observe in a gross form in the lungs and heart; for the same conditions are involved, whether the spirit is to be driven through the fibres, or the blood through the vessels. The blood cannot be driven through its arteries without the reciprocal expansion and constriction of the heart; nor can the spirit be driven through the fibres, which are little canals and vessels analogous to the arteries, only more pure, without the reciprocal expansion and constriction of the cortical glands of the cerebrum, which on this account deserve the appellation of pure corcula or little hearts. Assuming or granting these points, the necessary consequence is, that every time the cortical and cineritious substance of the cerebrum, cerebellum, medulla oblongata and medulla spinalis, contracts, or constringes itself, the whole mass of these parts sinks down, and undergoes systole; but, on the other hand, undergoes diastole, when the same substance, I mean, the whole congeries, expands. This is the animation of the cerebrum,—using the term cerebrum in its widest acceptation,—that corresponds to the respiration of the lungs. We must now proceed a step farther. If the animal or nervous spirit, at the intervals of the constriction of these organic substances,—of the little hearts of the cerebrum,—is expressed by the cerebrum through the nerves and nervous fibres, of course it is ex-

399. From these premises it follows, that the lungs are the organs which open the scene of corporeal life, and constitute the gymnasium of its exercises; for by wonderful influx they conspire in the way of general assistance to all its motions, effects and actions, common and particular, natural and voluntary (*a*). For this end, the universal fabric of the body, and

pressed by the cerebellum into its grand sympathetic nerves, the par vagum and the intercostals: and granting this, it follows, that these nerves act during the same intervals, upon the fibres of the pulmonary plexus, and upon the fibres of the costal nerves; which cannot fail on the instant to act upon their muscles, and membranes; nor the latter to act upon the ribs, and thus upon the internal structure of the lungs. Hence it follows that the animations of the cerebrum, (using the term here again in its widest sense,) must necessarily be coincident with the respirations of the lungs: and the fact is still more plainly declared by the influx of the fibres of the above-mentioned cerebellar nerves, the par vagum and the intercostal, into all the viscera of the abdomen; and by the motions of those viscera agreeing exactly, and keeping perfect time, with the respiratory motions of the lungs, as proved in detail in our Analyses.

(*a*) If we only observe attentively one or two voluntary or natural actions, and at the time they are going on, fix our thoughts upon the operations of the lungs, we shall be convinced that the latter flow with their respiration into all those actions. For instance, if we follow this course with the act of sneezing, yawning, eating, wrestling, leaping, speaking with gesticulation, coition, or any of the numerous actions specified above (n. 374), we shall prove the point to complete satisfaction from our own experience: and indeed any good anatomist will indicate the particular muscles that are called into play, and shew how the lungs accommodate themselves to the respective inflexions of those muscles. It would be useless to descend for proof to the description of any specific action; for were we to trace one action through many, perhaps through all, of the muscles of the trunk, arms and legs,—were we to state that this action was produced by the pectoral, deltoid and subclavius muscles, by the serratus anticus major, serratus anticus minor, rhomboideus, cucullaris, latissimus dorsi, sacro-lumbalis, quadratus, and a multitude of other muscles, of both regions, and both quarters of the body; and in fact by such and such fibres or fascicles of those muscles; and that at the time, the lungs were inflated, extended, contorted, raised, or depressed, in such or such a manner; were we, I say, to

all its organic works, are so mutually connected and coherent, that there is no point whither the pulmonic respiration does not penetrate; nor is there a single fibre of a nerve which the lungs do not by a general assistance excite to action: most manifestly does this apply to the nerves and twigs of the par vagum and of the great intercostal, which are the principles of the natural operations (*b*); likewise to the nerves of the medulla oblongata and spinalis, which although determined by the cerebrum, yet in the body are themselves determinant of the actions of the

take this course, what light would come from it to enlighten or steady the mind? The most probable effect of such a multitudinous catalogue of unknown details, would be, to precipitate the mind from light, into the darkness of doubt, or interpose clouds between it and the rays [of its sun]. For this reason, I have deemed it prudent to abstain as far as possible from heaping up particulars of the kind; and every one will assuredly take the same course, whose object is, not to gain a reputation for abstruse learning, but to investigate truths alone, and nakedly set them forth.

(*b*) You will find this point established in the Chapters on the Pharynx and Œsophagus, and on the Trachea: for the large nerves mentioned above, descend along the vertebræ, and there fix their ganglia, conducting and collecting into them a host of nerves from the spinal marrow. Some of their trunks and fascicles plunge into the œsophagus, and go forth into the stomach about the cardia or superior orifice; some penetrate the fleshy part of the diaphragm; others, particularly the trunks, clothe themselves with the pleura, in a word, choose the path that runs down the middle of the stream of the pulmonary motion. Hence, when the lungs respire, and when likewise the vertebræ, the œsophagus, the diaphragm, the pleura, and the peritonæum, are carried beyond their natural situations,—then the respiratory action of the lungs must necessarily be communicated to those nerves; and the effect must be, that the motive fibres of all the viscera, which fibres are entered by those nerves, will be excited to a similar action. For according to all experience, whenever a nervous fibre is dragged or chafed, the motive fibre constructed by the nerve of the former fibre, is excited to action. If this be so, the animation of the brain and the respiration of the lungs cannot possibly differ or disagree. Were it otherwise, a manifold, and in fact contrary action would fall upon one and the same nerve, and no action at all could be the result.

will (*c*). While the cerebrum and cerebellum, by their rising and constriction, that is to say, by their animation, inspire all these nerves with living spirit, then the lungs for their part, by an analogous and consociate rising and constriction, that is to say, by their respiration, inspire them with an active and coöperating spirit, and carry on the causes to the effect: thus the lungs, in a secondary manner, incite and drive into circulation the very spirit of the nerves, or as it is termed the animal spirit. In order to enable the lungs to perform these ministrations, a peculiar organic form is bestowed upon them, and a natural faculty implanted in the form, whereby they have a free power of admitting any given quantity of the wind or atmosphere, and of opening in any direction, and any door they please, and thus disposing themselves, by means of the muscles of the thorax, abdomen, and neck, that is to say, by means of all the muscles of the body, to every possible angle of direction and mode of formation (*d*); and therefore of accommo-

(*c*) This follows from the first proposition, namely, that the respiration of the lungs extends to all points of the body, consequently also to all the nervous fibres, both those of nature and those of the will: and if action proceeds from the nervous fibres, it follows that the lungs concur by their respiration, to every action.

(*d*) That only the external muscles are made use of, to induce upon the lungs the various states of respiration, that is, to close and open the pulmonary pipes, or to fill one set of vesicles with air, and to empty another set, and thus to accommodate the lungs to every form of action,—this follows from our premises; for all is voluntary that is communicated to the lungs by the external muscles; but all is natural that comes to them from the nerves of nature, that is, of the cerebellum: the will acts from without to within, but nature, from within to without. If we examine one or two actions, and consider the influence of the respiration, it will become evident, that all the muscles of the body may be instrumental for the above purpose; for according as they variously expand or constrict the thorax, and open the field, that is, enlarge the space, so, and not otherwise, do the lungs rise and swell. The adaptation of the lungs to the actions of the will by the external muscles, is more manifest in the action of speech, than in any of the other actions of the body; and hence the varieties of this motion are so great that they seem contradictory to each other. Thus it is brought

dating themselves, by infinitely varying states, to what is done, and to what is to be done. For this end, the pulmonary air-pump is divided through the middle into two lungs, which are parted and separated by the mediastinum (*e*); these lungs are divided into lobes by deep notches and fissures (*f*); these lobes again into lobules, which hang like clusters from the branches of the pulmonic vine; and these lobules, in fine, into vesicles representing single grapes (*g*), which are the chambers and

about with contraction of the chest and sternum, with extension, with depression, with elevation; with a diversity of bendings of the vertebral column, and with the straightening out of the same; so that it is impossible to determine what muscle is about to operate upon the cavity of the thorax, unless the action be previously given or assumed. At one time there is a powerful action of the subclavius, serratus, trapezius, latissimus dorsi, and of many of the cervical and even lumbar muscles; at another time of one or another of the abdominal muscles, or of the diaphragm and all of them at once; at another time again, of the vertebral, intercostal and sternal muscles. Nevertheless, all these muscles do no more than adapt the trunk of the body to the arms, forearms, legs and feet, and thus expand or constrict the chamber of the thorax in divers ways, either inferiorly, superiorly, anteriorly, or posteriorly, in every possible direction.

(*e*) "The lungs," says Winslow, "are two . . . bodies, . . . filling the whole cavity of the thorax, one being seated in the right side, the other in the left; parted by the mediastinum and the heart," &c. (n. 387).

(*f*) It is well known that the lungs are subdivided into lobes, the right lung into three, or two and a half, and the left into two: the divisions are effected by obliquely-transverse fissures; and by these means the lungs in expanding are enabled to take advantage of all the space in the cavity of the thorax. Respecting these fissures Verheyen says, "Both the large lobes are subdivided into at least two others, and one of them often into three, or even four, by certain fissures running from the anterior margin toward the back part, and of varying depth: these fissures, however, so far as I have observed, never penetrate so completely as to cut a large lobe quite through." (*Corp. Hum. Anat.*, tract. iii., cap. xii.)

(*g*) The reader will find these parts accurately delineated in the tables of Malpighi, Willis, Bidloo and Verheyen. Respecting the vesicles, and the collections thereof termed lobules, see their discoverer,

receiving-rooms of the air that has been permitted to enter. For the same end also each bronchial passage is capable of being opened and shut *ad libitum* (*h*), particularly in its subordinate branches and ramifications, and in the doors leading to the lobules and vesicles, by an adaptation of external forces, and through the intervention and influence of the ligament upon the common coat of the lungs. Furthermore, every lobule and vesicle has the power of transmitting its own gentle zephyr through convenient anastomoses into the adjoining vesicles, and thereby into the remote vesicles (*i*); and thus of dispensing the air to every form of action, and to every use resulting therefrom; as may be seen still more plainly in the universal lungs of the insect tribes (*k*).

Malpighi, as cited above, n. 388; and respecting the mediate operation of the pulmonary ligament, see above, n. 394 (*n*).

(*h*) See above, note (*d*).

(*i*) Certain little branches or ducts of communication run between the lobules, vesicles, and tubular ramifications; and by their instrumentality, the particular air of one lobe is enabled to become the common breath of all: thus the air is summoned from one lobule into another, according to every requirement, and every state of expansion and contraction; and hence the air being once given, the lung is most perfectly adapted by it, which could not be the case if new breath were constantly drawn in by the trachea. This arrangement appears to be of the greatest use in the operations of speaking, singing, and eating. By its means, as we find by experience, the cavity of the chest may be disposed variously to a single action, that is, to every form thereof, while the quantity of air remains the same. For if we hold the breath, we may still in a degree vary the expansions of the lung, and accommodate them to the series of the action. Respecting the above communication Winslow says, "The cells or vesicles of each lobule have a free communication with each other, but the several lobules do not communicate so readily" (n. 387). And Malpighi says, "Between these membranes [in the interstices of the lobules] run a vast number of most minute vessels, coming from the lobules, and which go to the opposite lobules. The air is received and thrown out by these membranes, as it were by large intercommunicating cavities, and hence it may be squeezed from one into another" (n. 388).

(*k*) For example, in the louse, in which, according to Swammerdam's description, "From every respiratory point there runs a branch

400. The lungs also associate and marry the voluntary motive life which originates from the cerebrum, with the natural motive life which flows from the cerebellum; that is to say, during the waking state, when the will is dominant, and nature lies as it were asleep. At this time the bronchial pipes are half opened, the air vesicles half distended, the common ways or pedicles open, the doors unlocked, and the vessels and membranes so intent upon the commands and wishes of their ruler, that at the first intimation, they turn their hinges, and promptly rush into obedience. Such is the waking state of the lungs, and there is a similar state of all the muscles and sinews of the body, because there is a corresponding state of the cerebrum in the day time, when it holds the reins of the will (*l*). Nevertheless, nature shares the em-

of the trachea, which soon anastomoses with some other branch proceeding from another point, and both close into one canal; . . . so that the air which is drawn into the body by one respiratory point, may be conveyed through the whole" (n. 391). And in the rhinoceros beetle, "From the apices of the vesicles . . . other pipes break out laterally, which after again dilating into vesicles, in their turn form air branches, vesicles, and pipes. . . . It is likewise observed that many tubes occasionally arise from one vesicle." *(Ibid.)*

(*l*) It will be seen when we come to treat of the anatomy of the cerebrum, that the substances thereof, and particularly the cortical substance, are divided by perpetual interstices and fissures, forming one uninterrupted passage and permeable channel; and that during sleep these interstitial apertures are closed, and almost obliterated by the approximation of their parietes; and that hence the cerebrum collapses or falls down in sleep: but that when we awake,—when sleep is shaken off,—these foldings and interstices reopen, their parietes separate, and their space is increased; in which case the cerebrum may be said to waken up, and to employ its attention upon the several functions of the organs of the body. These points proved, the consequence is, that during complete wakefulness the cerebrum remains expanded, and elevated to a certain height, the height being determined by the degree of wakefulness and attention: so likewise its whole appendage of fibres, that is, the whole body, which assumes exactly the state as well as tone of its cerebrum. Of this also we have a clear perception, that during wakefulness, everything, in every part of the body, enjoys a kind of tension; consequently some parts, according to their organic form, are

pire with the will, for the latter only constringes the nerves and reins of the body, and keeps them constricted and drawn up, so long as it pleases; but as soon as it relaxes its hold, then nature takes up the government, and performs the contrary operation; as when we draw a bow, and then releasing it, shoot off the arrow, in which case the first act belongs to the will, the second, to nature, for the loosened string bounds back spontaneously, and the arrow flies to its aim (*m*). Inasmuch as this drawing and straining of the fibres continues in various degrees during the day, according as the will commands, it follows that the costal nerves and muscles, being in a corresponding state, keep the lungs semi-expanded and raised, and consequently perfectly ready to afford any desired coöperation; and thus render the voluntary actions alternate with the natural actions.

401. Although during ordinary, tranquil, and spontaneous respiration, the government is shared between nature and the

contracted; others are expanded; the muscular fibres particularly enjoy a kind of general elevation, which places them in perfect readiness to execute every command of the will; and in order that the state of their body may be similar to the state of their cerebrum, the motive fibres must be comparatively separated from each other, and all contracted or expanded to a certain degree. When contracted, then those of the lungs are half opened, and so brought into the state in which the air can flow in and out with facility. The reverse is the case in sleep, and then consequently, we have stertor, attended with deep and slow respiration. This is the general voluntary principle that prevails throughout our waking hours; the vast difference between which, as a state, and the natural state or that of perfect repose, must be evident from a mere comparison of the two.

(*m*) These points were explained above, n. 394, note (*m*). From what was there said it is evident, that the voluntary principle has a continual tendency to strain whatever is natural, or constituted by nature, beyond its situation, relations, and state; and that it is necessary that nature should be as continually restoring the latter conditions; which is the reason of the alternate rest provided by means of sleep. For nature proceeds from an intimate ground, in order and continuous series, to external things; but the will, in a contrarious torrent, from external grounds towards internal things. Wherefore the muscles subject to the will occupy the extreme circumference of the body.

will, yet in the concurrence of the respirations with actions originating from the mind, the will engrosses nearly the whole of the power, and pushes nature from her throne to a low and humble seat; for besides the intercostal and other muscles, which minister to the lungs in respiration both by day and night, the will also calls into action several others, belonging to the breast, the neck, the head, the abdomen, and the back, and marshals them in battle array against the forces and efforts of nature. The muscles to which I allude, are the pectorales, serrati, rhomboideus, cucullaris, abdominales, and many others, which, equally with those before mentioned, raise, depress, extrude, slant, and twist the ribs, the vertebræ, and the diaphragm, according to the simultaneous or successive determination of the fibres, more or less numerous, which are called into action by the command of the will (*n*). By these auxiliaries,

(*n*) In ordinary, or tranquil diurnal respiration, which is very similar to nocturnal respiration, the only muscles called into action, are the intercostals, and certain others that are supplied, and summoned to combined operation, by the branches of the costal nerves. But the case is widely different in extraordinary inspiration and expiration, as in wrestling, severe or laborious exercise, the evacuation of the bowels or the bladder, and the numerous other actions mentioned above, n. 374. If we make trial in our own persons, we shall clearly perceive, that for every different action, the ribs have to be raised differently, the vertebræ to be revolved or twisted differently, the diaphragm hollowed differently, in short the cavity of the thorax formed or shaped differently, that the effect may be communicated thereby to the lungs, and their inspirations and expirations. And so much is this the case, that in one and the same action, before its entire series is gone through, we have sometimes to play upon all the muscles that cover and protect the circumference of the body. The muscles that are made use of in such extraordinary respiration, are properly voluntary muscles, for at night they may be said to fall asleep, and to operate but little upon the ribs. But as they are fixed by their tendons and extremities to the ribs and vertebræ,—I allude to the serrati, pectorales, and other muscles,—they determine variously the cavity of the thorax, and consequently the respirations of the lungs, and adapt them to the actions of the body; and frequently expand the parts beyond their natural standard of intumescence, as well as on the other hand compress them below that of detumescence: so that it becomes necessary for nature to operate in a

the will not only inspires and keeps up the lungs, but also empties and compresses them, and according to the degree of wakefulness, intensity, and presence of mind in the actions, seizes the department and province of nature, and prostrates her authority.

402. In addition to their concurrence to the voluntary actions of the cerebrum, the lungs also superadd something from their own powers and properties, namely, a certain hardness, strength, softness, gentleness, or some other similar endowment (*o*): and moreover, all that the animal mind communicates

contrary way, by an effort of parts to their natural situation, relation or nexus, and equilibrium, and thus to concur even to inspiration; whereas in ordinary respiration she concurs only to expiration. Thus when a spring is raised by an external force, it rebounds spontaneously by its own elasticity; but when depressed by an external force, it rises up and restores itself by virtue of the same power: which is the reason why in certain forms of action, nature appears to concur to inspiration as well as to expiration. According to the law laid down above, all the voluntary muscles, when excited, tend to alter the natural state; and when they act violently, which they do in proportion to their tension, [or the intensity of the will,] they then undertake the very functions that nature herself should perform, and in this case leave her very little to do. Meantime, however, nature cannot fail to suffer, and to stand in need of prolonged repose and sleep, before she can restore to their proper position and relation, the parts that have received mischief, or been disturbed by such unwonted tension and exertion.

(*o*) This must be said to be in a certain sense proper to the lungs, although it is a kind of common effort, and the same as the effort of the cerebrum through the nerves. But the cerebrum cannot possibly produce effects of this kind, without the common assistance of the lungs. For instance, in wrestling, personal combat, and similar trials of strength, unless the lungs be forcibly inflated by means of the brachial, deltoid, and pectoral muscles, &c., and the air powerfully condensed in them,—the body, chest and arms would never get the strength, support, and hardness that are requisite for such encounters. So even in natural operations, as in the extrusion of the fæces,—unless the lungs pressed stoutly upon the diaphragm, the vertebræ, and occasionally upon the abdominal muscles, and by these means upon the stomach and intestines, and specifically upon the colon, the full effect could never be concentrated upon the rectum; the effect, I mean,

to the will, the will communicates to the pulmonic breath, and this, to the actions. Thus the lungs not only enter the forms of actions, in the way of provisional and corporeal principles, but also inspire them with a kind of fire; and thereby represent them in ultimate effects precisely such as they are intended to be in first principles (*p*). This is more clear from the diminutive actions of the larynx, namely, from sounds and speech, than from any of the other actions of the body.

403. The lungs extend the power of their breathing-apparatus not only around and below themselves into the viscera and masses of the body, but also in an especial manner above themselves into the trachea, the larynx, and the palate, with which they concur to produce, exalt, and regulate the sounds of singing and speech, in the same manner as the uterus concurs to conceive, nourish, and give birth to the offspring; and this, by so wonderful a power, that they can cunningly apply themselves

arising from the aggregation of forces. This is particularly conspicuous in minute winged insects; before they can expand their wings, feet, legs, proboscis, and claws, they are obliged to fill their pulmonary pipes with air, until they become quite tense and hard, which gives their bodies strength and stiffness, and enables them to creep and fly. See Swammerdam above, n. 391. The above fact is observed in the ephemerus, the silk-worm, and the rhinoceros beetle; and in the covered snail, which makes use of the air to protrude its body completely from the shell. "As the snail rolls its body out of the shell," says Swammerdam, "so in proportion it drives the air into the cavity of its verge; and again, in proportion as it draws its body back, in the same proportion it expresses the air from thence," &c. (n. 391). So in like manner we make use of the pulmonic air to induce softness, yieldingness, and many other states, upon our own persons.

(*p*) As in all the affections of the animal mind, to which the qualities of motions or actions correspond,—in anger, fury, heroic valor, frenzy, fear, mercy, pride;—that is, when our breasts are swelling, drooping, sinking in, or trembling. As this is manifested by the actions of the body, so it is manifested in speech, by the harshness, shrillness, or sweetness of the sound, and instinctively interpreted; and in the face, by the expression. Some of the natural instincts of insects seem to be determined into effects in a similar way; for the animus of the cerebrum involves a corresponding animus in the fibre, and consequently in the lungs, which concur to the effect in a general manner.

to the actions of the body, at the same time as to the little actions of the larynx; like those who cultivate the player's art, and combine the voice harmoniously with the instrument, and the word with the action. When the will by education has become imitative or mimetic, it causes the lungs to produce the notes of sound, much in the same manner as the blast of the mouth causes the trumpet, or as the finger causes the flute, to bring forth musical or melodious notes. Just so the will, governing the muscles, awakens its pulmonic lyres; these, the tracheal pipes and strings; and these again, the laryngeal harp, from which the melody issues forth (*q*). The continuously successive series of causes down to the ultimate sonorous actions, appears to be as follows. The muscles of the thorax, together with the true respiratory muscles, keep the two pulmonary bellows inflated, balanced, and raised up, the air being invited and driven into the last vesicles, that is, into those nearest to the surface (*r*). The diaphragm adapts itself closely to the concave

(*q*) In the Exposition of the Larynx and Trachea, I endeavored to shew, that singing and speech are pure acts of the will, and that the breathing made use of for these purposes is altogether different in origin from extraordinary respiration; the former being simply expiration, that in this case is performed by the command of the will, but which, nevertheless, in ordinary respiration, as we stated above, is left to nature: so that in these little actions the will performs the part of even expiration; in fine, the lungs first draw such a quantity of breath, as they intend to bestow upon the entire series of the speech or song; which breath they so dispense, that no more comes forth than is sufficient for the voice, and the relative height thereof. Consequently in this operation the lungs are raised to a certain standard, the vesicles are extended, and the pipes half open; and so much air is pressed out of them by the action of the muscles of the body, as is meant to enter each point or division of the sound. We may all experience this in our own persons, by putting our lungs in the state of preparation for loud shouting.

(*r*) It is a necessary consequence, that before we are prepared to speak or sing, the air is determined into the vesicles nearest to the surface, inasmuch as external impulsion forces out the air that is to come forth in the shape of sound. That the air may be determined in various ways into the vesicles, is evident not only from their mutual communication, (see above,) but also from the first direction which the air

surface of the lungs (*s*). The abdominal muscles, the sacrolumbalis, and many of the subpectoral muscles, gradually drive up this septum from beneath (*t*): and by means of the ligaments, the pleura, and the common coat of the lungs, press the ve-

takes when the lungs are artificially inflated, namely, to the outermost or most superficial vesicles; as is well known from observations. "When we inflate the lungs," says Winslow, "the bronchial cells nearest their outer surface appear like small masses of round vesicles; and from this appearance they have all got the name of vesicles, though they are all angular, except those which I have now mentioned" (n. 387). Malpighi expresses the same thing still more plainly (n. 388). Thus there is a direct passage leading all the way to the superficial vesicles, although the air is also sent into the internal vesicles, or those next the bronchia.

(*s*) This is evident from the extension and contraction of the thorax in accordance with the oblique direction of the diaphragmatic plane; and from the operation of the muscles of the lower region upon the diaphragm, and by this means upon the lungs, for the extrusion of the air. The lungs in their natural position, lie upon the diaphragm, and are very closely united to it in inspiration and expiration, and are in contact with it at innumerable points, because by plane surfaces.

(*t*) Besides the abdominal muscles and the sacrolumbalis, there are also the psoas, the quadratus lumborum, the semispinosus and the longissimus dorsi, which have one of their extremities fixed to the vertebræ or ribs. All these muscles operate upon the diaphragm, by means of the vertebræ, the ribs, and the interposing viscera of the abdomen, and push it in towards the lungs, and thus force out the wind; as we may all observe in our own persons. This view is confirmed rationally also, by the fact, that the action cannot be brought to bear upon the lungs in any other way than by means of the diaphragm, consequently than by an action upon the diaphragm; for the ribs merely enlarge the thorax, but the point of compression cannot be determined by them; particularly as the lungs in both inspiration and expiration, are at a distance from the parietes, that is, are not in contact with the pleura [costalis], according to the observation of Morgagni (n. 390); but are not at a distance from the diaphragm, but sometimes absolutely adherent to it, according to the experience of Verheyen, *Corp. Hum. Anat.*, tract. iii., cap. xii. A further proof is furnished by the ligament, that connects the middle surface of the lungs to the vertebræ, that is, to the pleura, which is continued and united to the diaphragm.

sicles, and squeeze out the air (*u*). The air, driven from the cells by these external or voluntary forces in conjunction with the internal or natural forces, rushes with a strong impulse against the opposite parietes of each bronchial ramification, and from these again in like manner in a contrary direction against the parietes of the bronchial trunk, and ultimately against those of the trachea, and thus against the membranes, tense as they are throughout, the squamous pieces and little cartilaginous circles, consequently against elastic, vibratory objects, which will never suffer a stroke without returning as much as they receive (*x*). The air thus stricken and perpetually rever-

(*u*) "Under the root of each lung," says Winslow, "that is, under that part formed by the subordinate trunk of the pulmonary artery, by the trunks of the pulmonary veins, and by the trunk of the bronchia, there is a pretty broad membranous ligament, which ties the posterior edge of each lung to the lateral parts of the vertebræ of the back, from that root all the way to the diaphragm" (n. 387). By the action of this ligament, all the propulsive force that converges by means of the muscles upon the diaphragm, is immediately diffused over the whole of the external surface of the lungs, and particularly over their nearest or concave surface; so that not even the minutest motion of the diaphragm can exist, but it is propagated around the lungs by means of this ligament. The diaphragm is a membranous plane, formed by the pleura, the peritonæum, and certain intermediate muscles, and connected to the vertebræ, which are placed at the extremity of its median line. Hence when the diaphragm suffers impulsion, all the force concenters upon this line, consequently upon its extremity, where the ligament is situated, and the latter instantly conveys the active force to the middle part of the lungs,—their noblest and as it were polar portion, inasmuch as the arterial, venous and bronchial trunks, which produce the whole of the substance of the lungs, all meet together in that spot. Consequently again the force is immediately diffused over their whole circumference, and gives rise to a compression of the most superficial vesicles of the lungs, exactly corresponding with the degree of impulsion of the diaphragm. The intermediation is no obstacle to the effect, since all things proceed according to the order of nature, namely, from surfaces to centres, from centres to surfaces.

(*x*) It appears from the figures of Malpighi, Willis, Verheyen, Bidloo, and other anatomists, that the bronchia come off obliquely from the trachea, the subordinate trunks obliquely from the bronchia,

berated, encompassed wherever it goes with the tremblings of the membranes, and accompanied by tremblings of its own, is rolled through the trachea into the larynx, where, in the mouth of the glottis, by the educated vibration of the arytænoid cartilages, it is moulded into the form of sound, that is, into either singing or speech. The lungs do no more than supply a quantity of sonorous wind; but the larynx, the palate, the tongue, and the lips, set forth and dispense the same,—inflect, draw out, and divide it; in a word, reduce it into measured quantities and periods (y).

and the branches obliquely from the subordinate trunks: so that when the air is squeezed out forcibly and expelled from the vesicles, it rushes with a degree of impetus against the opposite parietes, and after being reflected from them again and again, issues forth in serpentine or rather angular volumes, having impinged upon every point in its way. When the lung is inflated with air, and determined towards the diaphragm, it is in a state of expansion, as consequently are all the membranes that invest the branches, and the cartilaginous plates and circles that beset the bronchial pipes. "These bronchia [or air-vessels]," says Winslow, "are conical tubes, composed of an infinite number of cartilaginous fragments, like so many irregular segments of circles, connected together by a ligamentary elastic membrane, and disposed in such a manner as that the lower easily insinuate themselves within those above them" (n. 387). Thus since the air strikes upon all points of such membrane, now in a state of tension, as well as of the cartilages lying in its course, all the way to the top of the trachea, therefore these parts must of necessity be set in vibration, and originate a tremor, which in its turn must originate sound; for the tremor must be dispersed into the escaping and fugitive air; according to what was laid down in the Chapter on the Trachea.

(y) The discrimination or articulation of sound appears to take place nowhere but in the upper part of the larynx, in the palate, the mouth, and the orifice of the lips; as shewn in the Chapters on the Larynx and Trachea. Thus it is caused both by the closing of the lips; by the opposition of the tongue against, or its application to, the arch of the palate, or the gums; and by the folding together of the velum palati, and the simultaneous expansion of the ventricles of the larynx, which lock the rima glottidis beneath. There is no apparatus in the trachea and the bronchia, anywhere excepting at this upper part, that is competent to close or stop off the passage against the air and the

404. The consequence or conclusion from the foregoing premises is, that the brains and the lungs concur with unanimous spirit to produce every effect in the body; and they are moreover so absolutely united by nerves, membranes, and organic powers, like two balances or scales containing exactly equal weights, that the one moves when the other moves, and the one stands still when the other stands still: hence if the breath of the one be suspended, that of the other stops; no matter whether the suspension originate from a cause in the cerebrum,—in its nature, or its will; or from a cause in the lungs, the larynx, the palate, or the mouth; that is to say, whether it originate from an internal or from an external cause (z). Thus the lungs open the motive, but voluntary, life of the body, and at the same time enable the will to reign in conjunction with nature; and if they open the motive life, then they also initiate the sensual life of the body: for wherever there is action, there is also will; wherever there is will, there is also

sound; and the less, because the lungs, and their tracheæ and pipes, are at this time in a state of expansion, and enjoying the freest determination towards the trachea. This is the way in which the air appears to be dispensed quantitatively; for the lungs contain and put forth just enough of it to suffice for the entire series of the phrase,—so much as will last until the next stop or pause, when they again draw in the right proportion.

(z) The internal causes alluded to, belong properly to the brain; that is to say, they exist when the brain wills to commence or terminate a sound or sentence; this being within its power and choice. Among internal causes are also to be classed those morbid states that affect the brain in such a manner that it cannot rouse itself into action. It is also the part of the will to induce upon the lungs the state that is suitable for the production of sound; likewise to intercept the breath of the lungs, by the interposition of the tongue, the folding together of the velum palati, and the closing of the lips; and to excite the muscles designed to act upon the diaphragm and the lungs: hence no private peculiarity is left to the lungs, excepting the fabric and power whereby they are enabled to comply with the will of the brain, in short, to suffer themselves to be properly acted upon. Thus, corresponding to the organic form of the lungs, and consequent upon it, we have the sonorous effect in speech and singing, of which there are such infinite varieties, both natural and accidental.

perception; and wherever there is perception, there is also sensation (*a*). Wherefore, inasmuch as the will is the beginning of actions, and is the end of sensations, therefore the lungs in instituting the one life, also institute the other.

405. But we must now pass from the consideration of the spirit or breath wherewith the lungs animate the universal kingdom, to the consideration of the blood which the lungs drink from the mouth of the heart, and return into its other chamber. For the blood, collected from innumerable venous streams into the right auricular cavity and ventricle of the heart, swollen and adulterated with chyle and vapor, fresh and obsolete,—with chyle and vapor that has not yet been triturated and refined, but is undigested, vaporous and flatulent;—this blood,—mixed and confused, as in a rude chaos, in mutual implication and entanglement, with the pure, spirituous, florid,

(*a*) For there is a connexion and everlasting chain between sensations and actions. Sensations mount up to intellectual perception; from perception they pass into thought; from thought, into a kind of conclusion; and at last terminate in the will, which is determined to a particular action corresponding to the desire for the contemplated end. Hence the form of the perception, thought, conclusion, or understanding, determines the form of the will; and the form of the will determines that of the action. And if no action can exist without involving an intellectual principle, or some analogon thereof, so neither can any sensation. For sensation presupposes a mind percipient of the objects of the senses,—it presupposes that the voluntary motive life of the body keeps pace exactly with its sensitive life. It is very evident that the lungs produce both these forms of life, since when the pulmonary pipes or the trachea are obstructed and suffocated, powerlessness immediately seizes the limbs, darkness and insensibility overspread the organs of the five senses, and a cloud overshadows even the imaginative and intellectual faculty: thus the soul, deprived of its organic media, is forced to resign its body. It is not so during uterine life, before the lungs are opened, and before their conjunction with the brains, with respect to their animations, is rendered absolute. At this time the law does not hold, that the lungs move when the brains move, and stop when the brains stop; because then, as we before pointed out, the brains synchronized their animatory reciprocations with the systolic and diastolic motions of the heart.

and youthful blood (*b*),—the lungs eagerly and thirstily snatch and swallow through the venous or pulmonary artery, and convey along the bronchial passages to their intimate chambers and secret cells; and on the way, they divide the disorderly mass, by continual acts of severation, in their branches, capillaries, and tufts, and ultimately, down to its unities, which they lustrate or purify singly or particularly in their little reticulations (*c*). After this, whatever is sanguineous, or kindred

(*b*) It is well known, that all the medley that can possibly be scraped together by the veins from the extreme and intermediate regions of the body, is collected in the right chamber of the heart. Thither the liver pours forth all its chyle; thither the mesentery pours forth all its chyliferous streams, gathered from the stomach and intestines; not to mention what the roots of the veins imbibe from the glands and vapors of the body, and from the atmospheric world, through the skin: in short, thither goes all the wash, mixed with genuine chyle and blood, which the internal and external worlds supply. For so long as we are governed by the will, and the will itself is tossed by the desires of the rational mind and the lusts of the animal mind, so long a pure stream cannot possibly be absorbed by the little veins; but whatever favors and corresponds to the ruling principle of the animal mind, will be carried into the blood; in anger, for instance, black bile and broken pieces or quantities of serum and blood. All these converge into the right chamber of the heart; and in addition thereto, undigested chyle, correlative to an ailing body or mind; chyle enclosing windy or aërial particles, that escape in the form of flatus or dense vapor, when the undigested particles of such chyle are resolved into their principles. "Air," says Boerhaave, "has been sometimes found, in considerable quantity, in the heart, the coronary vessels, and the large arteries." *(Inst. Med.*, n. 201.) On this subject he refers to Ruysch, *Epist. Anat.* xvi.; Sylvius, *Disput. Med.* vii., § 86 (Amstelod., 1670); and Swammerdam, *Tract. de Resp.*, p. 98. (Lugd. Bat., 1679.) Thus the heart is no more than the receiving vessel of the miscellaneous medley that is constantly being gathered from the whole body into one heap, sometimes without any selection, for the purpose of generating the blood, and driving it into circulation.

(*c*) When nature is either founding a world, or renewing one that she has already founded, or which she intends to exist perpetually, that is, to subsist, she generally precipitates it into a confused chaos, or unintelligible vortex; in short, she brings together into one all things

thereto and consanguineous, they transmit into continuous veins; but whatever is discordant and heterogeneous, whatever is merely a dead weight and a useless burden, hostile to the marriage of the chyle with the spirit, and windy or flatulent, they expunge and banish out of the bronchial and vesicular lobules into the cells of the interstices, and there work and knead by reciprocal powers of constriction, and express its liquid from its thicker parts (*d*). But the lungs do not throw out the whole of this impure humor, for the veins select and reabsorb the part available for the blood; the lymphatics im-

that can conduce to its existence and renewal; as we observed above in the Chapter on the Liver, n. 205 (*k*), into the sinus and porta of which organ she brings together all the impure chyle and blood. But she provides causes, or as here, in the animal world, applies an organ, whereby the confused heap is divided, distributed into parts and members, and completely examined and purified. By this means, those things that are suitable are taken back into use, and the rest are thrown out. We have a clear instance of this plan of creation in the case of the heart, and in the conjunction of the heart with the lungs. The whole continuous mass and quantity of the blood is thrown confusedly into the heart, and specifically into its right chambers, with the ulterior purpose of being all transmitted into the lungs, which sunder this confused volume into its individual parts, and reduce it to a discriminated quantity; so that there is not a single globule of blood or particle of chyle, that does not at length flow solitarily, that is, by itself, in its own branch. In this way, all the sanguineous forces of the heart are counted out singly, and if we may use the expression, man by man, in the lungs: and of consequence, the thick parts are exquisitely removed from the liquid parts, the inert from the elastic, and the corporeal from the spirituous, and beautifully arranged for future use.

(*d*) These points need no comment at present, because they will be self-evident as soon as the experimental proofs that follow have been established. To assist the reader's perception, I am obliged to premise the series and account of the operations, and to demonstrate that series afterwards by the effects which the industry of anatomists has brought to light. But the particular mode in which the serosity of the vessels is kneaded and compressed, when thrown out into the cellular interstices, will be shewn at the end of this paragraph, in note (*c*), where the details of the operation are explained.

bibe the spirituous part, when sublimed to the surface, while the cellular tissue carries off the spume that is left, and extrudes it through foramina, leading uninterruptedly from the vesicles to the larynx, into the bronchia and trachea. Thus the lungs clear away the dross and impurities of the blood, and purify and correct the undigested contents of the heart, divided, according to nature's wonted manner, into their individual parts (*e*); at the same time that they eructate and banish the air, the mortal enemy of the blood, in the form of effete and vapid halitus and vapors. In this manner they are the prime and general strainers or Colatories of the blood, and the Evaporatories of its sweats (*f*). The foregoing statements are corroborated by the concurrent testimony of many circumstances; as, 1. The reticulations of blood-vessels in the intimate recesses of the lungs (*q*); and in the external parts of the pulmonary bladders of those animals which have no proper lungs (*r*). 2.

(*e*) See above, note (*c*).

(*f*) They are called Colatories, because they separate the sanguineous essences by filtration or colation; and Evaporatories of the sweats of the blood, because they also operate by the evaporation of the parts secreted. The whole circumference of the skin is in one sense an evaporatory of the sweat, but not a general evaporatory like the lungs.

(*q*) There are vascular networks of amazing fineness in the internal membrane of the bronchia and bronchial ramifications: of these we shall treat in the next paragraph. Similar networks are found on the external surface of the lungs; but particularly around the vesicles, and in the interlobular interstices; and cannot fail to separate the parts of the cardiac blood down to their unities, and to purify each particle individually. Of [these networks, that is of] this rete mirabile, Winslow says, "All the bronchial cells [or vesicles] are surrounded by a very fine reticular texture, consisting of the small extremities of arteries and veins which communicate every way with each other" (n. 387). Again he says, "In the substance of the [fine internal] membrane are a great number of small blood-vessels." *(Ibid.)* And Malpighi states that "When a small piece of the external substance of the lungs is held up against the light, we see a singular network or rete mirabile; . . . and the same rete is observed in the interiors of the lungs when a section is made, although in this case less distinctly" (n. 388).

(*r*) Fishes and numerous living creatures of that description have only a bladder or bag in the place of lungs; but blood-vessels ramify

The uninterrupted interstices and cellular tissue surrounding the arteries, veins, and air-tubes, and continuous and permeable on the one hand all the way to the trachea, on the other hand all the way to the surface (*s*). 3. The numerous lymphatics and veins

over the surface of this bladder, forming wonderful plexuses and meshes, and winding in circles to and fro, as in the kidneys. Thus on the same principle as the little gyres in the kidneys, they tend to secern and expel from the blood the humor that is unsuited and repugnant to its nature. The reader will find these vascular circumflexions figured in the plates of Malpighi and other anatomists. "The blood [of the frog]," says Malpighi, "driven by the heart's impulse, rains down in the manner of a vapor or effluvium into the minutest parts, running through the arteries into all the cells, by one or another of the considerable branches that pass through them, or terminate therein; and thus divided and subdivided, it puts off its red color, and following a sinuous and circuitous course, is scattered on all sides, until it reaches the parietes and angles [of the cells], and the reabsorbent branches of the veins. . . . In the oblong lung of the tortoise, . . . it was very evident that the blood ran in a divided state through the tortuous vessels, and was not effused into the intervening spaces; in a word, that it always passed through little tubes, and was thrown about in a complex interlacement of vessels" (n. 389). And Swammerdam says, "Toads, water-newts, lizards, chameleons, tortoises, serpents, &c., are provided with membranous lungs. . . . The heart of the frog, like the hearts of fish, has only one ventricle, with one artery issuing from it, . . . which soon divides into two trunks. . . . The first of these, which is the least, goes on each side to the lungs; . . . and in its course divides commonly into three little branches, and then proceeding outwards to the coat that surrounds the lungs, forms thereon a truly wonderful vascular network. From thence the branches also pass down by very small shoots into the irregular internal vesicles of the lungs, among which the pulmonary vein is diffused, and with the latter they form a remarkable anastomosis" (n. 391).

(*s*) All anatomists are unanimously agreed, that the cellular substance surrounds and encloses not only the whole of the lungs, but also all the essential determinations; I mean, the air-vessels or bronchia, the arteries and veins, and the nerves; just as occurs in the liver, the spleen, and somewhat also in the kidneys; which shews that this circumstance obtains in all the viscera, and is the ordinary rule of nature. That the vessels of the viscera are enswathed in a capsule or sheath;

opening with their little mouths in these hollow recesses (*t*). 4. The multitudinous foramina pervious and open from this tissue

the spaces filled up with cellular substance or padding; the proper vessels of the viscera perforated with little holes, in order that the sweat discharged therefrom may be taken up by the interstices, and evaporated through a continuous lattice-work towards the surface; that little venous mouths open along the whole of the way; and lymphatics on the surface; and that the passing humor is partly absorbed by the veins and lymphatics, and partly rejected,—all these points have been shewn in our analyses of many of the viscera. Respecting the cellular tissue that is continued from the surface of the lungs to the trachea, see the preceding Chapter, on the Trachea. Speaking of this tissue, Winslow says, "It is dispersed through every part of the lungs, and forms cellular or spongy sheaths which surround the ramifications of the bronchia and blood-vessels, and is afterwards spread over the outer surface of each lung, where it forms a kind of fine cellular coat, joined to the general covering of that viscus. When we inflate this interlobular substance, the air compresses and flattens the lobules" (n. 387). See Malpighi on the same subject, n. 388. The vascular rete mentioned above, extends particularly over the membranous web of these interstices, as appears from Malpighi's figures and description: and hence, if any secretion is carried on, (and that there is a secretion cannot be questioned,) the drippings thereof must necessarily fall down into these cells, and so be sent forth into a field where they can be absorbed by the veins and lymphatics, and whence the residue can be rejected and squeezed out, as caput mortuum or fæces: as must especially be the case since these little spaces are expanded and contracted during every expansion and constriction of the bronchia, and the lighter matters thrown upwards, and the heavier downwards. "The last ramifications of the pulmonary artery," says Boerhaave, "reticularly overspread the surfaces of the vesicles, and in like manner the intermediate cellular spaces, and after forming an infinity of arterial anastomoses, they at last terminate in the veins. . . . The alteration in shape of the cellular spaces, and their enlargement in size, &c., . . . must occasion . . . the blood, and all the other humors contained in the several pulmonic vessels, to be reciprocally pressed, propelled, shaken together, liquified or thinned," &c. (*Inst. Med.*, n. 198, 200.)

(*t*) Respecting the lymphatics of the lungs, Verheyen says, "The lungs are provided with an abundance of lymphatics, which arising by almost an infinite number of little branches that for the most part accompany the blood-vessels, and afterwards uniting into a few small

into the bronchial ramifications, the bronchia and the trachea (*u*). 5. The experimental evidence furnished by the inflation of air into the bronchial vessels (*x*), and by the injection of

trunks, run ultimately to the thoracic duct." (*Corp. Hum. Anat.*, tract. iii., cap. xii.; and tab. xxiii., fig. 1.)

(*u*) Respecting the foramina with which the internal membrane of the trachea is perforated, and respecting the cellular substance of the trachea, which is continuous with that of the lungs, see the preceding Chapter on the Trachea. Respecting the corresponding pores and foramina in the bronchia and their ramifications, Winslow says, "We may observe very distinctly, sometimes even without a microscope, a great many small holes in the pedicles of the lobules, and of the bronchial cells, that is, of the vesicles that immediately surround the bronchia, which holes open from within outwards" (n. 387). That this porous structure opens both ways, namely, from the interstices into the cavities of the bronchia, as well as from the cavities into the interstices, may be inferred from the respiratory air itself, which unless great force be used, never escapes from the bronchial pipes into the cellular interstices; whence it appears that there is a more free and open passage from the interstices into the bronchia and trachea [than the contrary way]; or if you please, that there is a reciprocal passage, according to the circumstances of the case. There is a very free communication between the cellular substance and the trachea, for when the membranes are gently compressed, humor gushes into the trachea. Nor is there any other way of discharge for the collected ichor, although meanwhile the arteries are constantly pouring a humor into these spongy interstitial spaces. "They [the bronchia]," says Winslow, "are lined on the inside by a very fine membrane, which continually pours out a mucilaginous fluid" (n. 387).

(*x*) It has been a point of dispute among anatomists, or at any rate of earnest inquiry, whether or not the air of inspiration escapes through the openings of the bronchia into the surrounding cellular spaces. Malpighi appears to have adopted the affirmative view without hesitation (n. 388). Afterwards Morgagni took the opposite side of the question, having been led to this course by his own observations. "When a knife was passed," says he, "through the middle of the interstices [cellular spaces], so as to divide the lobules from each other, and the flame of a taper was held to the divided parts, and the air driven frequently and forcibly through the bronchium, . . . in this case, although we always saw the lobules dilated, in no instance was the

colored fluids into the arteries (*y*). 6. The quantity of viscid humor occupying the follicular spaces of the lungs, and causing various morbid affections (*z*). 7. The viscid humor of a similar kind covering the branchiæ of fishes, in which an analogous process of percolation is carried on (*a*). 8. The fœtor that

flame ever so slightly disturbed or shaken" (n. 390). But Winslow, on the authority of Helvetius, asserts that air blown with force into the bronchia and vesicles, escapes at last through the foramina into the interstices. His words are as follow; "When we inflate the bronchial [cells or] vesicles, they presently swell, and if we continue to blow with force, the air passes insensibly into the interlobular substance" (n. 387). Again he says, "When we blow through a pipe introduced so far as to touch immediately a trunk of the blood-vessels or bronchia, the air runs at first through all the cells that lie nearest that trunk or its branches; but if we continue to blow, it insinuates itself through the whole interlobular tissue." (*Ibid.*) If then in deep inspiration the air penetrates from the bronchia into the cells, it must necessarily pervade the cellular tissue, and escape ultimately either low down, into the bronchia, or else into the trachea; which is a proof that the viscid and useless secretion of the arteries is also discharged by this way; as we may indeed perceive to be the case by the breath.

(*y*) Malpighi's observation goes far to prove, that not only the pituitary refuse thrown out by the arteries of the lungs into the interlobular or interbronchial cells, but also the flatulencies escaping from the undigested particles of the chyle when broken down by compression and agitation, are expressed and discharged through the foramina into the bronchia and trachea, and through no other path. The observation to which I allude is the following: "After injecting ink through the pulmonary artery, I have frequently seen it escape from many parts; thus, on slight compression, it exudes in part from the investing membrane, and collects in part in the interstices, but the greater portion comes out mixed with blood through the pulmonary vein; and what is remarkable, it issues in a diluted state and of a lighter color through the trachea, accompanied with a thin froth; this takes place every time the lungs are squeezed. . . . Something of the same kind appears to take place when mercury is injected" (n. 388).

(*z*) This is the origin of the numerous morbid, and in a certain sense glandular corpuscules found in diseased lungs; respecting which, we refer the reader to the records of medical cases, and to n. 410 of this Work.

(*a*) In fish and other creatures of that description, the cardiac

strikes the olfactory papillæ in the expirations, being not completely sheathed or concealed by the vapory halitus. 9. The blood itself pronounces and declares the same thing on its own behalf; for all that is venous in the blood, is poured by the heart into the lungs; and all that is arterial is poured back, changed in nature, appearance and condition, that is to say, become florid, lively and brisk, by the lungs into the heart (*b*). 10. And indeed, when poured back, it is found to have been reduced in quantity in the filters and strainers of the lungs; for the vein which goes into the left auricle of the heart, is less than the vein which goes up into the lungs from the right ventricle of the heart (*c*), contrary to the usual habit of nature in other parts of this kingdom.

blood is not all carried through the vesicular lungs, but the greater part of it goes to the branchiæ, which are hence blood-red in color, and are exposed to the air, to enable them to expunge immediately those humors that are hostile to the blood. Malpighi shews that the branchiæ are besmeared with a viscid moisture. "Inasmuch," says he, "as mucus may be always rubbed from the gills [or branchiæ] with the greatest ease, it is not inconsistent to suppose, that what in other animals goes out by the kidneys and the skin, is thrown off in fishes by this compression" (n. 388).

(*b*) The blood returned by the lungs to the heart, is swift, purple, and ruddy, and of a very different character to the blood sent by the heart into the lungs, as we shall shew in Part III., when we come to speak of the Heart. Rational considerations are also in our favor here, for the blood that passes back into the heart's left ventricle, is deprived of its tardigrade companion,—the livid, thick, and useless serum,—which is ejected by the above-mentioned ways of discharge.

(*c*) It will be observed, that I still continue to call the conduits of both the arterial and venous blood, veins; and it is my intention to point out in the sequel, that the blood of the lungs, which runs through the pulmonary artery, is of a venous character, and becomes arterial for the first time in the vascular networks surrounding the vesicles. In the meantime, we shall find it most convenient to follow the received terminology, and to call that vessel which proceeds into the lungs from the right ventricle of the heart, the pulmonary artery, and its branches, arterial branches. But to come to the point in hand. Winslow says, speaking of the pulmonary artery, "It must be observed, that the ramifications of the arteries are more numerous and larger than those

406. As the lungs load the air thrown out by expiration, with the adulterations and impurities cleared away from the

of the veins, which in all other parts of the body exceed the arteries in number and size" (n. 387). And Heister says, "It has been a matter of discussion with some anatomists, why the pulmonary artery is larger than the pulmonary vein, whereas in all other parts, the veins are larger than the arteries," &c. (n. 385). The circumstance here alluded to is a plain indication that the arterial blood has deposited a considerable amount of matter in the lungs,—that it has thrown aside a quantity of lading into the cells. But before finishing the present paragraph, it appears to be required that I should describe more fully the process adopted in the purification of the sanguineous mass; and shew, that the lungs do not really purify the blood, but only correct its serum, and as we said above, work and knead the latter by reciprocal acts of constriction, and express its liquid from its viscid parts. The circumgyration of the capillaries on the parietes of the cells, and on the surface of the vesicular lungs in some of the lower animals, clearly demonstrates that the lungs reject the serosities there in large abundance, throwing them out of their vessels into the cellular interstices. Thus the reticular vessels of the lungs exhibit almost the same circumflexion as the vessels of the kidneys; which latter secern the serum from the blood, and reject its stale and urinous portion. From the parallel between the two cases, we may infer, that the retia mirabilia of the lungs in like manner extrude the unclean and undigested sera of the blood into the cellular interstices; and compress, shake up, and express them therein, much in the same manner as the spleen does the blood, which it squeezes out of its vessels into similar spaces, and teazes by reciprocal acts of compression, as shewn in our analysis of that organ. The experimental proofs just recounted and laid down, is convincing as to the fact, that a similar compression and teazing of the serum, although not of the blood, goes on in the lungs. And it will be seen below (n. 408), that the cellular compages of the lungs is extended in length, and contracted in breadth, during each act of inspiration; and that precisely the reverse is the case during each act of expiration. The serous mass, therefore, is continually reduced to straits, and purified in this way; the liquid parts are separated by compression from the thick parts, the shapely from the shapeless; the former being reabsorbed by the veins and lymphatics, while the more viscid and flatulent parts are injected in the form of froth or spume through foramina into the bronchia and trachea, whence the largest portion of them is discharged, either by expiration, in the way of

blood, so they thoroughly examine the air attracted by inspiration, and alternately a welcome guest; and should it have brought any rich or choice presents in its vaporiferous bosom,—any members of the volatile families of salts, sulphurs and nitres,—the lungs suck them in delightedly by their veins: although as soon as ever they have enjoyed the banquet, they throw out the air as the most deadly enemy of the blood (*d*),

vapor; or by expectoration; or else insensibly, by progressive reptation in the direction of the palate.

(*d*) It is evident from many considerations, that the air is the deadliest enemy of the blood; the arteries reject it, and the veins spit it out, and both of them turn from it as a hostile and heterogeneous thing; and hence it seems never to be able to get into the blood by fair means, or otherwise than slyly and stealthily, namely, when enclosed in undigested particles of chyle, on the breaking up and opening of which, it flies out and shews itself in the current. But as we may conclude from many of the symptoms of disease, the arteries and veins are always seriously affected by its presence, and always labor until they have expelled it. This is the reason why the flatulent matter that escapes from the particles of the chyle during their resolution in the lungs, mounts along the cellular tissue into the trachea, and comes out there through the foramina in the form of froth. This also is the reason why the natural functions of the viscera suffer from the air, whether enclosed in the stomach, or in the intestines, and specifically in the colon, or in the cavity of the abdomen, or in that of the pleura; and why the air is driven out and eructated at the first door that offers. The ground of this hostility will be evident, if we contrast the properties of the blood and the air respectively, when we shall discover that there is a natural antipathy between the two. But before we can undertake to reason from causes, we require to have a knowledge of these properties. Thus the air is to the highest degree elastic, expansile, compressible; it is tumid when exposed to heat, compressed and collapsed when exposed to cold; swift and baggy when in motion; and its particles are larger and lighter than those of water. The [particle of] blood, on the other hand, although possessing some elasticity, does not permit of expansion and compression, but merely suffers intrinsic changes,—changes internal to itself and confined to its own body, and acts in the quietest manner with the neighboring [particles]. When, therefore, it is in company with the air, it experiences a state of inquietude, for the air disturbs and violates its internal re-

and as we said before, load it like a mule with a baggage and burden of adulterations, and force it to carry them out (*e*). Let us now consider more minutely the successive stages of its immigration and arrival. The atmosphere, impregnated with effluvia exhaled abundantly from the three kingdoms of nature, and filled with odors, fragrant or the reverse, is attracted in volumes by the spiracles of the nares. The olfactory papillæ exquisitely anticipate whatever is concealed in these volumes, whether favorable or unfavorable to the pulmonic blood; if favorable, they imbibe it with open lips, and carry it home, as consisting of nectareous dainties and preserves, into the very depths of the vesicles of the lungs; but if hostile, they keep it out of doors by the compression of the alæ or pinnæ, and dread its approach, and chase it away. But the nares carefully supervise and examine whatever they admit for the sake of breathing, and invite for the sake of refecting the blood; all heavy and inert particles, sooty flakes, saline spiculæ, miasmata, and the

lations, and ruptures the kindly alliance between the chyle and the spirit; nay, it carries off the elements of the chyle, and the spirit itself, and throws them into its vapors. Indeed, were the air to get into the little ramifications of the arteries through the large branches, it would completely block up their mouths, and preclude the entrance of the blood, and congregating in dense vapors, enormously distend the little canals, as we know that it distends the intestines; and so on in other respects. For these reasons, the air is admitted no farther than the pulmonic vesicles, which constitute the last term of the ramifications of the heart, and the first term of the ramifications of the lungs. Hence it is driven out, to prevent it from penetrating too far, and this, by the means described above. Nevertheless, for the sake of the gifts and presents that it brings, it is a welcome guest; for it carries in its bosom, as companions of its winged career, the first elements of salts and sulphurs, and proffers them liberally to the universal mass of the blood, on these frontiers, or in these first and last boundaries.

(*e*) Agreeably to what we explained in the previous paragraph, to wit, that the air carries out those things that are secreted from the blood, for instance, undigested, windy matters, which would be of no value in the circulation of the blood, and which are thrown among the vapors. These matters are what we term the baggage or lading of the air.

like, which are of great weight and no value, they ensnare in their viscid mucus, and bury in their moist lacunæ. Those matters which go past the nares, are similarly purified by the trachea. The bronchia likewise assist in the work, and finally their subordinate branches and ramifications, upon all points of which the intruding air impinges. Thus the air, closely examined at every corner of the way, and emunged of its impure accompaniments, at length comes to the lungs in their smallest form, namely, to the vesicles, and now warm and bathed in vapors, it has nothing in its bosom but what is friendly to the blood,—nothing but delicate and welcome presents, which the veins, omnipresent in their little atmospheric world of the vesicle (*f*), and hungry after all their losses, must eagerly seek out, select and imbibe. Thus the blood, fed and feasted with occult, ethereal, and heavenly food, and no longer turbid and cloudy, but serene, florid, purple, joyous, lively, and worthy of marriage with the spirit, has already put on the arterial robe. But the air which is only the ministering attendant for bringing and proffering these gifts to the blood,—lest it should insolently rush, as it attempts to do, into the bed of the blood, and pollute its marriage,—is driven out headlong, and loaded with fines and burdens (*g*). Thus the lungs, by virtue of their office, are not only the *Colatories* and *Emunctories*, but the *Refectories*, of the blood, the *Preparatories* also of the blood from venous to arterial, and the *Lustratories* of the air. This view is confirmed by a multitude of facts, which by their clear bearing upon the point, convert what were before opinions into natural inferences. For, 1. The atmosphere conveys and carries about in its bosom, not a mere wave, but a whole ocean and cloudland of effluvia (*h*),

(*f*) The atmospheric vesicles may be said to resemble the grand atmospheric world, as a least volume resembles its largest; for the air floats, gravitates, and puts forth its powers, within the sphere of the vesicle, in the same manner as in the grand sphere of the atmospheric world.

(*g*) See above, note (*d*).

(*h*) Respecting the vast quantity of effluvia contained in the atmosphere, see Boyle and other writers on physics. The fact is, that effluvia are exhaling continually from all the pores of the subjects of the

by which the smell is affected, the state of the animal mind changed immediately from confusion to serenity, or from serenity to confusion; the blood suddenly awakened, or benumbed with torpor; and the life raised up as by a breath from heaven, or withered by contagion (*i*). 2. Sleep, cataphora, ca-

mineral kingdom, as is clearly evidenced by the magnet; from all the subjects of the vegetable kingdom, as is proved to sensible demonstration by the odorous emanations from tracts of woodland and garden ground, flower-beds, shrubberies, and the like; from all the subjects of the animal kingdom, as is well established by the acute sense of smelling possessed by dogs, and by the sagacity and power of nose with which they follow wild animals, merely by their track, or even by the air. This crowd of effluvia cannot fail to follow the attracted halitus and air into the innermost recesses of the lungs, (see n. 375;) and inasmuch as it necessarily consists of quantities of different particles, shapely and unshapely, congruous and incongruous, heavy and light, inert and volatile,—particularly of oleaginous, nitrous and sulphureous particles,—hence it becomes imperative that some warning sense should be stationed at the first doorway, as well as that there should be a mucous lymph in certain lacunæ, whereby these particles may be netted in a kind of snare, and the pure portion separated from the impure. Of this we have a clear perception by the sense of smell, in places that are filled with the vapors of sulphur from furnaces or mines; in such places, the palate, the trachea, and the cavities of the nares are beset and roughened by the fumes and exhalations, and the very color of the mucus which we spit out, attests a manifest ensnaring of particles, and a percolation of the air. Proceeding by the chain of causes from these evident signs to others which are less evident, we can hardly avoid the conclusion, that a similar filtration goes on in the bronchia and their branches, inasmuch as they are covered with a similar viscid moisture.

(*i*) As in garden grounds, beds of roses, and shrubberies in the time of spring: from the influence and sudden effect of particular spirits and volatile essences, and which is powerful enough to refect the blood: on the other hand, from poisons and contagions, that affect the blood in divers ways, communicating to it either a torpor, or a chill, or fevered heat and fire; or even kill it outright with their first blow or breath: and from many similar facts, which may be read in superabundance in the records of medicine and physics. Unless the above effluvia passed into the blood by way of the lungs, it would be quite impossible for them to produce these great alterations,—it is impossible that

rus, and even ecstasis and catalepsy, nourish the blood with a kind of mystic food. 3. Many persons have prolonged life for months, years and ages, without taking any ordinary [terrestri] sustenance (*k*). 4. And not a few species of animals, and those of the most voracious kind,—for instance, bears,—live for a very considerable time in a state of natural asitia, and are actually fattened when they come from their winter dens; to say nothing of vipers, chameleons, and a number of other creatures (*l*), which if they do not feed upon effluvia, nevertheless, in the act of inspiration, enjoy a foretaste and perception of what is suitable to the blood in their daily food (*m*). 5. We may also

they should produce them by the mere sense of smell. By parity of reasoning, we may conclude from these things, to those which we are momentarily inhaling and conveying into the blood in our ordinary inspirations.

(*k*) The reader will find a number of accounts of such persons collected by different authors; for instance, by Simon Majolus, Caspar a Reies, Marcellus Donatus, John Schenck, Daniel Sennertus, John Jonston, John Rudolph Camerarius, Quercetanus redivivus [Joseph Duchesne], Caspar Bartholin, J. J. Doebelius. But it would be useless to insert such accounts in this place.

(*l*) It is, I believe, pretty well known, that bears and their cubs live altogether without prey or food throughout the winter, buried under the snow in their dens and caves, and only sucking their paws, and yet that in the spring they come actually fattened out of their winter tombs. Now if we collect and sum up the evidence afforded by such circumstances, we shall arrive at the conclusion, that these animals were nourished during their period of hybernation entirely by the air which they breathed. Similar phenomena observed in vipers, snakes, frogs, flies, crickets, field-mice, marmots, land-tortoises, silk-worms, crocodiles, snails, ostriches, chameleons, and other creatures, are too frequent to allow of any doubt as to the fact.

(*m*) We are all aware that animals know by the smell the food that is suitable to their nature, and hence it is impossible to doubt, that they foretaste the effluvial particles of the food, in the first instance by the lungs and the blood of the lungs; and so immediately begin to have a clear perception, by virtue of the nature that dominates over them, of what is suitable to them, or unsuitable: for by the mere affections of their animal mind and nature they take cognizance of the very harmonies or accords of things, under the form of pleasantness or un-

gather confirmations from anatomy, for the parietes of the bronchia and vesicles are beset with congeries of veins (*n*), which greedily snatch all those things that will appease the hunger of the blood, and after taking what will be beneficial,

pleasantness, consequently of love or aversion; just as we also perceive all the harmonies of nature, by nature alone, by means of the affections of our animal mind. This is the reason why beasts possessing the above powers of smell, draw their breath so very deeply and profoundly at the food offered to them, and convey the vapors exhaling therefrom almost into their very vitals, as we have plenty of opportunities of observing in such cases and under such circumstances. It is a common remark, resting upon ample experience, that we are sometimes almost satisfied by the mere smell of victuals, for instance, in kitchens; and that we may be inebriated by vapors, for instance, in wine-cellars. That these and similar effluvia and vapors are attracted into the blood, not only through the insensible pores of the skin, but also by the inspirations,—of this we may be instructed still more definitely by anatomy, from the little venous oscula or orifices in the bronchia and vesicles.

(*n*) Respecting the number of vessels in the bronchia, Winslow says, "They [the bronchia] are lined on the inside by a very fine membrane, which continually pours out a mucilaginous fluid; and in the substance of the membrane are a great number of small blood-vessels" (n. 387). The same is the case in the vesicles, as demonstrated by Ruysch, who threw a wax injection into the pulmonary vein, and found it exude into and fill the hollow vesicles. (*Thes. Anat. Max.*, n. 59, 102.) So that it appears, that little venous mouths stand open in all parts, gaping for the proffered food. It is of no consequence whether effluvia float in the air in the form of humid vapor, or whether they are in combination with any of the humors when applied to the lips of the little veins; since the veins drink and eat whatever comes to them in a pleasant and eligible form. I explained the causes of the appetency and elective property of the veins in Part I. of this Work. Thus much is evident, that when the air has penetrated through the bronchial ramifications, it becomes exceedingly humid, and contains scarcely anything but vapors; for in the whole of its course, it strikes upon dripping membranes, and saturates itself with moisture. This vapor, constantly circulating in the vesicles, cannot fail to be presented to the little lips of the veins, for when in circulatory motion, it leaves not a point of the parietes untouched.

reject all those things that are inimical to the blood (*o*). 6. Moreover, the blood returned into the arterial or left auricle and ventricle, is visibly changed in character, just as it would be by exposure to the air, or by mixture with a saturated nitrous solution (*p*). Nor must we omit to notice the proof

(*o*) But it will be asked, what kind of aliment or chyle the air impregnated with effluvia can bring into the blood, when so great an abundance of chyle is supplied by way of the blood-vessels and lymphatics from the stomach and intestines, which are the proper chylopoietic and sanguigenous organs? If we carefully consider the blood, and its embodiment or bodily constitution, we shall soon be convinced, that all the elements necessary to enter it, cannot possibly be supplied by the ventricular chyle. The nutrition of the human body is nothing else or more than the nutrition of the blood. The blood is the common seminary and cornucopia from which all things are taken that will give nourishment to the body. Now in order to the conception and generation of the red blood,—in order to its composition,—we require, not only water, which serves as the vehicle and medium for giving currency to, and presenting and introducing, those elements, but other elements besides, such as can only be obtained when the connexions of the chyle are thoroughly dissevered, and its particles broken open. Of these elements, there must be some that will consociate the blood with the chyle; others that will enter the blood itself, and copulate its red globules with their [formative] white or pellucid globules; and others again which in their turn will constitute the white or simple blood; and the latter elements must be of a more primitive and pure nature than the former. In a word, the existence of the two kinds of blood, presupposes a concurrence not only of all classes and species of material elements,—of all things that lie stored up in the bosom of dead nature, —in the earth and the domain thereof; but also of all things that are floating in the air, and of all that are floating in the ether. Hence the animal being must elect and borrow the grounds and constituents of its blood from the whole circumambient world. But to describe the specific properties of the chyle expressed from the food of the stomach; of the chyle drawn forth from the air; and of the purer chyle invited through the skin from the ether,—this must be the result and end of our Analysis. Consequently I shall not venture to offer it as a mere statement, nor in fact until I have premised the requisite experimental evidence which I have to bring forward in the proper season.

(*p*) The experiments instituted by Malpighi and other anatomists,

derived from, 7. The branchiæ of fishes, by which the blood is brought into contact with the air, to go back into the system, refected with atmospheric food (q). By these means it is ordained, that whatever exists in the world or universe of nature, —whatever is laid up in the great bosom of things,—shall minister and yield compliance to the subjects of the animal kingdom, and preëminently to their blood. This then is the ultimate function,—the final office of the air.

407. When this sanguineous chaos,—this crude and undigested volume,—has been driven through the filters of the lungs, purged of its discordant parts, and skimmed of its impure phlegm; when furthermore it has been saluted with atmospheric kisses, enriched with occult, celestial aliment, and

shew that when blood drawn from a vein, and suffered to stand for a while until it becomes livid, lurid and dusky, is exposed to the air, or besprinkled with nitre, it takes on a lively, purple, and flaming hue. "Six ounces of nitre in solution," says Malpighi, "introduced into the jugular vein of a dog of middling size and strength, produced no sensible change, excepting an abundant secretion of urine; in other respects the animal continued in perfect health. . . . When powdered nitre, or nitre in a state of deliquescence, is placed upon blood, it produces upon the surface a thin crust of a deep purple color; and the same thing occurs, when aqua vitæ, common salt, rock salt, sal ammoniac, sulphur, and hartshorn, are made use of in the same way. Nearly all these substances appear to retard the coagulation of the blood for a short time." (*De Polypo Cordis Dissertatio*, ad fin.) Again he says, "Thomas Cornelius admitted the existence in the blood of a certain exquisitely fine halitus; and this, not merely as an *ens rationis*, but as a thing obvious to the senses, inasmuch as it reeks from warm blood, and impresses the palate and tongue with its sharp saline properties. This, he thought, might properly be termed the salt or balsam of life, because by virtue of its agency, the blood particles enjoy freedom of fluxion, and the whole of the body, life and vigor. This salt of life is eliminated by the lungs by means of fermentation, either from the liquids brought by the blood, and particularly from the lymph, or as I incline to believe, from the external air, since the lungs themselves are analogous to glands in structure." (*Ibid.*)

(q) In fishes the chief part of the blood is propelled to the branchiæ or gills, which in other animals is propelled to the lungs. See Malpighi, n. 388; Swammerdam, n. 391.

raised thereby to a higher power of radiance,—then the portion of it that flows into the veins, and passes into the left chamber of the heart, is arterial (*r*); and its very serum is so virgin and marriageable, that wherever it finds the spirit unmarried or single, and comes into relation with it, there it forms a speedy alliance (*s*); the issue of which is a ruddy, flaming, and refulgent blood, a parent so prolific that the universal body is its offspring and its common progeny. Now since the blood con-

(*r*) This is in truth a consequence from the two preceding paragraphs. For the venous blood collected in the right auricle and ventricle of the heart, continues to be of the same character, that is, venous, throughout the pulmonary artery, all the way to the vesicles; in fine, to the very innermost reticular plexuses; during all this course it continues to be undigested, indiscriminate, mixed with fresh and effete chyle crammed together,—a heap of things with various properties. But as soon as it is separated from incongruous or heterogeneous matters, and impregnated or tinctured with ethereal aliments, then it assumes an arterial character. Hence the character and properties of arterial blood as distinguished from venous, consist not merely in fluidity, redness and weight, but also in a kind of glittering splendor. Of these characteristics we shall speak in Part III., in treating of the Heart, the Arteries, the Veins, and the Blood. In the meantime we refer the reader to n. 409 (*q*).

(*s*) If we understand the composition of the genuine blood, that is, of the red globules, we shall find that what is termed the animal spirit constitutes its principal essence, and that the primitive elements of salts or sulphurs are adopted simply for the sake of connexion, and produce its corporeal essence. In order to the existence of the genuine blood-globule,—of such a globule as will perform the part of a soul, or the purposes of *the* Soul, in the body,—it is absolutely necessary that the superior universal essences should enter it; for upon this depends its power of acting, and its faculty of accomplishing aright its allotted functions; and from this its life takes its principles and its destinies. In truth, did we not live our life in single parts, consequently in the single individualities of the blood, we could not possibly live in the whole, or in the general congeries of the parts; that is, in the body. The general life is but the sum and complex of the individual lives. But the quality of the life depends upon the organization of the parts and the whole in which the life resides: respecting this we shall speak in the proper place.

stantly maintains its venous character and mixed indiscriminate condition, all the way from the right cavern of the heart to the rete mirabile and intimate villi of the lungs, therefore it seems proper that the pulmonary artery, as it is usual to term it, should rather be considered as a *vein*; yet again since it has one distinguishing mark of an artery, in that it diminishes in calibre and increases in the number of its ramifications, in the direction of the sanguineous current, and in its ultimate capillaries separates and excretes various essences from the blood, therefore it would appear, that it may deservedly and *ex officio* be termed an *artery*. And if we put these circumstances together, and think fit to denominate this vessel at once from its peculiar blood, and from its function, then we shall find that we cannot bestow upon it any term more appropriate than its ancient name of *venous artery* or *arterial vein* (*t*).

408. Two points now demand exploration, namely, with what systole and diastole do the pulmonary arteries and veins pulsate, and under what government do they act, under the government of the heart, or under that of the lungs; for thus much is certain, that the heart pours its blood with spontaneous readiness into the pulmonic channel and its pipes, and that the lungs drink it with eager mouths and veins (*u*). According to

(*t*) We give things names, either from their internal states and inferred properties, or from the phenomena they manifest in operation, or from their visible forms and the crude notions to which these give rise. But it is of little importance whether we call a thing by this name or that, provided we understand by the name the essence of the thing signified and indicated. In fact it is exceedingly trifling and empty to spend any great pains upon alterations in terminology. With respect to this pulmonary vessel, it causes no difference in our ideas, whether it be termed the pulmonary artery, or the venous artery; but since the ancients denominated it the venous artery, my intention in this place simply is, to shew that that name expresses it rightly; and I am the more justified in this course, since it does not in any degree divert our attention from the contemplation of the real matter in hand.

(*u*) We shall find if we examine the connexion between the heart and the lungs, that the lungs are in a certain sense the appendages and productions of the heart; and not *vice versa*. Passing by the fact that the heart existed before the lungs, and long before their motive life

the facts revealed by anatomy, and confirmed and attested by the phenomena of respiration, the following appears to be the progression. The blood, sent from the heart into the lungs, as its grand capsules or appendages, never stops until it arrives in the last meshes and reticulations, that is, in the field of leasts, or in the parietes of the interlobular cells (*x*), where it flows

began, and at this time had the government of the body; it is clear that the heart continues and propagates itself, that is, its muscular substance or parenchyma, not to the lungs, but to the great artery, and thereby to all the arteries of the body; but that it propagates to the lungs only its outermost surface or robe, namely, the pericardium; which forms a capsule that invests both the proper and common vessels of the lungs; in fine, the true cardiac vessels. This capsule, or continuation of the pericardium, penetrates to the very innermost parts, and constitutes the cellular tissue that surrounds all the vessels. "The pellicles which compose it [the cellular tissue]," says Winslow, ". . . appear to form a true sheath" (n. 387). Hence the continuation of the pericardium is identical with the continuation of the cellular tissue around the blood-vessels and bronchia, respecting which we refer the reader to the citation from Lancisi on the subject of the Pericardium (n. 419). From this propagation it is evident, that the true muscular structure of the heart,—or the heart viewed organically, does not extend to the innermost parts of the lungs; but that this is the case with only its most general covering, the pericardium, within which its [pulmonary] artery and vein proceed continually in the lungs. From these considerations it may be concluded, that the heart, in entering the lungs by the pulmonary artery, throws itself out of its own primary and peculiar sphere, but still keeps constantly within its own ultimate sphere: and inasmuch as it produces the latter, and disposes it into an organic form, therefore this form or structure is its appendage, wherein its blood is in discriminated quantity, or multitude, while in the ventricles, on the other hand, it is in continuous quantity or magnitude.

(*x*) The plates of Malpighi give the best idea of the reticular division and ramification of the vessels at their extremities, and of the rete mirabile of which that Author is the discoverer. According to him, the rete lies upon the outside of the vesicles, and is in a manner adherent to them; but he also figures a similar rete on the parietes of the cells. (*De Pulmonibus*, tab. i. ii.) "The ramifications of the . . . vessels in the lungs," says Winslow, "are surrounded everywhere by the cellular substance [of the interstices], . . . and the rete mirabile of Malpighi,

round and round in a perfectly free arena. In these intimate goals and centres reside the essential pneumonic power and nature, as well as the circulatory power that propels the blood in the lungs. In other words, from these centres the lungs govern their circumferences to the farthest limits in all directions; namely, to their external covering, to the beginning of the trachea, and to the two entrances of the heart, where the venous artery flows in, and the arterial vein flows out (y). It is evident from the reciprocal stretching and relaxation of the cells, while the lungs are inhaling and exhaling the breath, that these reticulations constantly thirst for the blood, and demand it from its branches and trunks, and from the cardiac bed, and that they as constantly send away and refund it into the other bed or cavity of the heart; but not alternately, that is to say, not during the intervals of inspiration and expiration. For the reticular meshes of blood-vessels that form the parietes of the cells, are half extended and half relaxed during every

. . . is formed by the capillary extremities of these vessels" (n. 387). This network or rete, being the last station of the arteries proceeding from the heart, and the first station of the veins returning to the heart, is therefore the hinge and turning-point of their fluxions.

(y) The large vessels are to be regarded as intermediates, which tend to these networks as their terminations. In this light we are to view the bronchia, which end in the vesicles; and so also the interstices, which are the ultimate retreats and resting-places of the vessels. In these centres or intimate recesses, the lungs begin to be what they are; in other words, from these centres they derive their nature; from the vesicles their pneumonic nature; from the vascular networks their sanguineous nature: so that the lungs may really and deservedly be said to govern their circumferences from their centres. For in the centres they perform their secretions, as we shewed in a preceding paragraph (n. 405); in these chambers they receive their Æolian guest, wherewith they excite the whole of their circumference to motion, and rouse it into storms. Their ultimate boundaries are the two cardiac entrances, the trachea, and the membranous investiture; to which boundaries or circumferences there is a continuation from the innermost parts. From the foregoing considerations we may infer, that the cardiac blood runs out until it reaches these goals, in order that it may return to the starting-place, and enter the kingdom of the body with the palm or prize wherewith it has been crowned at the goals.

act of breathing; thus while they are increased in length they are diminished in breadth, and *vice versa* (z). These meshes

(z) In order to facilitate the understanding of these particulars, I will explain the matter a little more clearly. The interlobular or cellular substance, which like that of the spleen is composed of a tissue of membranous follicles, is extended in length every time the bronchia are filled with air; for it is united to the bronchia, and in a certain sense continuous with them and the vesicles: on the other hand, it is contracted in length every time the lungs expire the air. Both circumstances strictly follow, and will become quite comprehensible, provided we take a mechanical view of the action that goes on between the bronchia and the continuous interlobular substance; that is to say, of the operation of the one upon the other. Suppose a number of vesicles of any form you like, grouped together lengthwise and breadthwise in rows, and draw them out in either direction;—of course the areolæ or planes running transversely must be in a state of relaxation, at the time the other set is in a state of extension: natural necessity as well as experience shews that such must be the case. "The lobules," says Winslow, "appear distinctly to be parted by another cellular substance, which surrounds each of them in their whole extent, and fills up the interstices between them. This substance forms likewise a kind of irregular membranous cells. . . . [It] is . . . spread over the outer surface of each lung, where it forms a kind of fine cellular coat, joined to the general covering of that viscus" (n. 387). And again, "The pellicles which compose it [the cellular sheath of the vessels] are . . . disposed there in a more regular manner, and more longitudinally than in other places." *(Ibid.,* ad fin.) Thus when the bronchia are filled with air, and expanded in length and breadth, the surrounding cells necessarily undergo a change of condition, and are themselves extended in length, but contracted in breadth. The contrary to this happens in expiration, and the cells are extended in breadth, but contracted in length. Something similar is caused by inflating the interstices of the cellular tissue, when the air so much increases the extension with respect to breadth, that the pressure makes the vesicles angular. "When we inflate this interlobular substance," says Winslow, "the air compresses and flattens the lobules." *(Ibid.)* We may then come to the conclusion, that these cells with their vascular rete are always in a state of expansion as well as of contraction, one half of them constantly alternating through these states with the other half. Those which are in the state of expansion, are in a state of systole, and are expelling their blood into the veins, and their serum into the empty

govern the large arterial and venous branches and stems proceeding along the sides of the bronchia (*a*); and the fibres of

interstices. On the other hand, those which are in a state of relaxation, are in a state of diastole, and are inviting and admitting the blood; in the same manner, in both cases, as in the heart: so that in the one instance there is a perpetual invitation of the blood from the right side of the heart; in the other, a perpetual expulsion of the blood towards the left side. This statement is greatly corroborated by the following observation of Malpighi. "When a ligature is put upon the [frog's] auricle and heart," says he, "and the motion and impulse prevented that might otherwise be communicated by the heart to the vessels, still the blood is sent by the veins towards the heart, so as by its force and quantity to distend the vessels; and this lasts for several hours: but at length . . . the blood ceases to be actuated with the same continuous motion, and fluctuates, as if impelled by fits, going backwards and forwards the same way; which will occur even when the heart and auricle are torn off.—From certain circumstances . . . we may infer, that the rete, . . . intermingled with the vesicles and cavities, serves . . . as an afferent and efferent vessel for the mass of the blood" (n. 389).

(*a*) The large vessels, arterial and venous, run along the sides of the bronchia, and have the latter between them: but respecting the varying relation of these three kinds of vessels, in the lamb and the human subject, see Morgagni, n. 390. During the contraction of the bronchia, or during expiration, the blood-vessels contract, so as to form rugæ. "In drawing out any portion of the bronchia by the two ends," says Winslow, "the [cartilaginous] segments are parted, and the whole canal is increased in length; but it contracts again by means of its elastic membrane as soon as the force is taken off. When we open lengthwise any portion of the pulmonary artery and vein in the same lung, we meet with a great number of transverse rugæ, which are obliterated when these vessels are elongated. This is an observation made by Helvetius" (n. 387). Thus the large blood-vessels are expanded and contracted solely by the inspirations and expirations of the lungs; likewise the nervous fibres, which also run along the bronchia; wherefore they act upon the blood-vessels during inspiration, but cease to act during expiration. Hence the pulmonary vessels are placed completely beyond the sphere of the heart's activity, and undergo no systole or diastole, excepting when they are excited thereto by their nerves, which can only happen during the intervals of the respiration. The same conditions occur in the rete mirabile itself, but with this difference, that

the pneumonic plexus, alternately elongated and shortened by the breathing of the lungs, institute this everlasting play. Thus the lungs hold the reins of their blood-vessels, and leave the heart no power over them, excepting with respect to the importation of the blood; and by the very condition of their nature and structure, they continually thirst for a fresh supply, and continually reject the old supply (*b*). The truth of these statements is corroborated by a number of circumstances; as, 1. The ready reception and as it were invitation of the blood from the right chamber of the heart; and its ready ejection, and as it were spontaneous return to the left cavity of the heart; that is to say, after the lungs have once been opened or filled with air. 2. The course of the blood-vessels, within a capsule put forth by the heart, and along both sides of the ramifications of the trachea. 3. Their foldings and doublings during the contraction of the lungs. And, 4. Their reticular division and ramification in the cells of the interlobular tissue. 5. The similar division and ramification of the fibres of the pulmonary plexus (*c*). 6. The evident harmony subsisting between the circulation of the pulmonary and the circulation of the cardiac blood (*d*). And many other circumstances to be

one half of its vessels is in a state of extension or diastole, at the time the other half is in a state of contraction or systole; which consequently is also the case in this part with the nervous fibres that excite the vessels of the rete to action. The rete mirabile may be compared to a fibrous sponge, which once wetted, and squeezed or wrung out, attracts fluid with rapidity, if ever so small a corner of it be placed therein. So when the rete is emptied,—its serosity expressed into the cells, and its blood thrown into the veins,—any part of it, in its then state of relaxation, instantly sucks the blood from the large branches and trunks, and attracts it greedily: precisely as we find to be the case in other minute porous bodies. This is the reason why the intimate constituents of the lungs draw forth the blood from the right ventricle of the heart, and why its reception becomes so easy after the lungs have been once filled with air.

(*b*) See note (*a*) just above.

(*c*) All these circumstances have been discussed in the observations immediately preceding.

(*d*) Were it not for the above dispensation of the blood, namely,

found in medico-anatomical records will furnish fresh points of corroboration.

409. But besides the pulmonary arteries and veins,—as it were, the mistresses,—there are also certain handmaids and domestics, termed the bronchial arteries, which (arising either from the great artery, at the beginning of its descent, or from one or more of the intercostals, or from the œsophageal, or from some other root connected with the intercostals, in some cases as a single vessel, in others by two trunks, one answering to each lung, in others again by almost as many trunks as there are lobules (*e*),) take the same course as the former vessels,

its continual invitation from the heart, and continual impulsion into the left auricle, it would be utterly impossible for such wonderful harmony to subsist between these two proper viscera of the thorax, which are so totally dissentient in their motion, and live in such entirely distinct spheres of activity. But if the lungs unceasingly desire and demand the blood, and receive it every moment in which the heart can pour it in; and if the heart's left chamber be constantly anxious to distend the arteries of the body with blood,—then in this case, the motions of these two viscera may be persistent, and uninterrupted by each other, and no stoppage or intermission will overtake them. Our present position might afford us an opportunity to canvass and discuss the question, whether the circulation of the blood originates from the heart, or from the intimate constituents of the lungs; but from the points established above, it is very evident, that the question is much the same as if in reasoning about the motion of a water-mill, we were to argue whether the motion began from the wheel, that is, from the heart; or from the stream that falls upon the wheel, that is, from the lungs.

(*e*) Respecting the bronchial arteries, see their discoverer, Ruysch, who has dedicated several plates to shewing their origin, course, and anastomoses. The origin particularly, of these arteries, has been investigated by many anatomists since Ruysch, and in all animals found to be too various to admit of a fixed definition. Nevertheless I shall endeavor to shew at the end of this paragraph, that they always arise from some stock connected with the intercostals. No writer, within my knowledge, has traced the various origins of these vessels more industriously than Winslow, and I shall, therefore, again transcribe his words, so as to bring them under the present view of the reader. "The bronchial arteries," says he, "come sometimes from the anterior part of the aorta descendens superior, sometimes from the first intercostal

skirting along the bronchia, all the way to the ultimate stadia and plexiform reticulations of the lungs (*f*). In fact, the bronchial arteries not only keep step with the pulmonary arteries, and accompany them to the very end of their walk (*g*), but even by frequent anastomoses join footsteps with them, and form a general alliance (*h*), and either retrace the way in com-

artery, and sometimes from one of the œsophageal arteries. They go out towards each lung, sometimes separately, sometimes by a small common trunk which afterwards divides to the right and left, near the bifurcation of the trachea, and they follow the ramifications of the bronchia. The left bronchial artery comes pretty frequently from the aorta, and the right, from the superior intercostal on the same side, because of the situation of the aorta. There is likewise another which arises from the aorta posteriorly near the superior intercostal, and above the anterior bronchial. . . . Sometimes one bronchial artery gives off several of the superior intercostals; sometimes several bronchial arteries send off separately the same number of intercostals" (n. 387).

(*f*) The bronchial artery follows the same course as the pulmonary arteries, running along the bronchia and their ramifications; as established by our Authors. "The bronchial artery," says Ruysch, "enters the lungs obliquely, and lying under the venous artery, accompanies the bronchia to the end, until it is lost to sight in fine capillaries." (*Dilucid. Valvul.*, cap. iv., obs. xv.) This is my reason for calling it a handmaid or attendant, for it is much smaller than the pulmonary artery.

(*g*) The bronchial artery, like the pulmonary, penetrates all the way to the reticular plexuses or ultimate filaments. This is evident not only from the observation just cited, but even more clearly from the following words of the same Author; "This artery," says he, "is connected to the bronchia, and accompanies them to their termination. In fact no human industry can point out a single branch of the trachea, however minute, that is not supplied by the ramifications of the bronchial artery." (*Epist. Anat.* vi.)

(*h*) Ruysch has proved by injection, and shewn in one of his plates, (*Epist. Anat.* vi., tab. vii., fig. 5,) that the pulmonary and bronchial arteries unite by numberless anastomoses. He also asserts the same thing in the following words: "In various places the bronchial artery anastomoses with the minute twigs of the pulmonary artery, as represented in tab. vii., fig. 5.; for when the pulmonary artery is injected with wax, the little branches of the bronchial artery are found to be

mon with them, to the left auricle of the heart (*i*), or else go out by particular passages, in the form of veins, to some branch of the intercostal veins, or of the vena azygos (*k*). The blood, running back through the bronchial vessels, but lately was blood in the pulmonary vessels, which now reascends, clothed in its own proper coat (*l*), to take the same course again and again, and serve the pulmonary vessel as a daughter and handmaid; for it follows their track, step for step, and as we said

instantly filled; and I have no doubt that the converse may also take place, although I have never tried to produce it." *(Ibid.)*

(*i*) It is evident from Ruysch's experiment just recorded (*h*), that the blood of the bronchial artery mingles with the blood of the pulmonary artery; and hence it is impossible to doubt that the blood of the former artery passes into the left side of the heart, in company with the blood of, first, the pulmonary artery, and of secondly, the pulmonary vein, and thus retraces the path which it has previously taken. Hence again it is clear, that the blood which enters by the bronchial artery, comes from the arterial and not from the venous blood of the body.

(*k*) Ruysch was not so fortunate as to discover the bronchial vein, but it was found and described by his followers. "The existence of the [bronchial] vein," says Winslow, "was questioned for some time, but it exists as really as the artery, and may be easily demonstrated. . . These veins are sometimes branches of the azygos, coming from the upper part of the curvature or arch. The left vein is sometimes a branch of the common trunk of the intercostals of the same side; and sometimes both veins are branches of the guttural vein" (n. 387). And Verheyen says, "In a sheep, I found that the bronchial vein had a common origin with the coronary vein of the heart." *(Corp. Hum. Anat.*, tract. iii., cap. xii.)

(*l*) This blood, running back from the aorta, or from one or more of the intercostal arteries, or from the œsophageal artery, now, as we before said, takes its second course through the lungs; differently from the rest of the arterial blood, which first completes its circle by passing through the veins, before it returns to its Lustratory, the Lungs. And if this same [bronchial] blood, mixed with the blood of the pulmonary artery, and thus carried back through the pulmonary vein into the left chamber of the heart, and so into the aorta, is recalled a second time through the bronchial artery, in this event it is clear that it has completed three circuits, during the time in which the remainder of the blood has completed only one.

before, associates and interweaves its branches with theirs (*m*). This artery, I. In conjunction with the twigs of the par vagum and intercostal nerves, was what conceived, engendered and constructed the embryonic lung, and all its vessels, aëriferous, arterial and venous (*n*); and laid down and formed those direct

(*m*) See above, note (*h*).

(*n*) Before birth, and before the opening of the lungs, that is, in the mother's womb, the bronchial artery and vein were the only vessels that supplied the lungs, and pervaded their intimate textures; for the entrance from the heart into the pulmonary artery had not then been opened; hence the bronchial artery must be regarded as the architect of the lungs,—as the vessel that built not only the minute air-pipes and vesicles, but even the cells of the interstices, and the reticular meshes, into the stamina of which, the pulmonary artery and vein are afterwards to flow. The universal fabric of the body is woven of nothing but the exquisite foliage and ultimate ramifications of the arteries and veins; for these are determinant of the lowest or corporeal universal essence, as was observed in the Chapter on the Peritonæum (n. 314, 315.) The nervous fibres flow into the blood-vessels, and thus mediately give rise to these compositions or creations; as it is my intention to shew more fully in Part III., in treating of the Heart, the Arteries, the Veins, and the Blood. The minute stamina of all the textures of the body are the products of the weaving or interlacement of the arteries, and though they appear white and in a manner nervous, yet during severe inflammation, and when exposed to the pressure of fine injections, they become expanded, and colored with sanguine purple. Thus the bronchial artery must certainly be esteemed the parent of the whole pulmonic texture; and no one will refuse assent to this opinion, when he recollects the absence of the influx of the pulmonary artery during the fœtal period. It follows from the same considerations, that there was also a vein present, which worked those tissues in conjunction with the artery, and returned the blood into circulation. Nevertheless, I cannot help doubting, that this vein can be conspicuous after birth in all subjects, since according to Ruysch's observation (*h*), the bronchial artery forms numerous anastomoses with the pulmonary artery, and does not send forth all the blood through the channels made use of in the primeval body, but on the contrary sends the greater part, if not all, into the pulmonary artery and vein, and so into the left chamber of the heart. On this subject Heister says, "I saw them [the bronchial veins] clearly and distinctly for the first time in a female subject:

passages along which the atmospheric air and the cardiac blood are to pass and glide in the second period of life: thus this artery was once the parent, but now the change in its fortunes has made it the daughter and the slave (*o*). II. It still performs a sort of parental office, for it in a manner runs before, and points out the way that is to be followed, as far as the reticular goals of the lungs, where it receives the pulmonary artery in the guest-chamber which it, (the bronchial artery,) formerly prepared (*p*); and teaches the former to play the artery,

they ran in several branches from the intercostal veins to the bronchia: . . . they are not, however, always to be met with" (n. 385).

(*o*) Proceeding by a continuous series of inductions, we cannot escape the conclusion, that the bronchial artery wove the channels, great and small, through which afterwards the pulmonary veins and arteries run; and hence that these pulmonary vessels pass within coats formed by the shoots of the bronchial artery. For if this artery constructed all these parts, then of course it must have constructed the coats and little sheaths for the cardiac blood that was afterwards to come,—for what is now the general pulmonic blood: on this account it is, that we say that the bronchial artery has ceased to be a parent and become a daughter,—has ceased to be a mistress and become a handmaid. The animal body is obnoxious to similar fortunes in other respects; for Nature, that was the mistress in the uterine or antirespiratory epoch, is subject after birth to the yoke and dominion of the will; that is to say, the essential active powers of the soul are subject to the efforts of the will: the knowledge possessed by the soul, which is a universal knowledge, is subject to the mere judgments of the rational mind; and the principle which bore sway in the state of integrity, now delivers up that sway into the hands of its own slave. But we shall speak further of these subjects in our Psychology.

(*p*) This is another branch of the conclusion necessarily resulting from our premises. For the bronchial artery now conducts the pulmonary artery in two ways to its ultimate and reticular stadia; in the first place it furnishes the coat of the pulmonary artery, since, as we before observed, it constructed the coats of all these vessels out of its own branches; in the second place, it pours its blood by anastomoses, into the blood of the pulmonary artery. And it is probable, that it retains a few capillaries of its own in these ultimate networks, inasmuch as Ruysch's injection thrown in through the bronchial artery ran all the way to the finest capillary threads; see above, note (*g*). Whether all

although it carries venous blood (*q*). III. The bronchial artery regulates, balances, and equalizes the respective quantities of the cardiac blood rushing into the lungs, and of the pulmonic blood returning into the heart; that is to say, whenever either organ labors under superabundance or deficiency of blood: for where there are two quantities actuated by different currents of motion, there must be some regulation, level, and equation; so that if either too much or too little, relatively to the desire of

the capillary ramifications are, or are not, common to the two arteries, I am not able to decide. But if in the reticulations the bronchial artery has threads of its own, and runs forth by them into the coats formed for the branches of the pulmonary artery; and if Ruysch's observation be correct, that it admits the blood of that artery, by means of anastomoses, into its own vessels, then it follows as a consequence, agreeably to our proposition, that the bronchial artery performs the duties of parentage, points the way for the pulmonary artery, and receives the latter in the chamber which before birth it (the bronchial artery) prepared.

(*q*) I endeavored to shew above (n. 407), that the pulmonary artery conveys, not arterial, but simply venous blood, and that, therefore, properly speaking, it is a vein and not an artery: but that since it diminishes in size, and increases in the number of its branches, in the direction of its current of blood; and since in its ultimate branches it performs, in respect of secretion, the office of an artery; that on this ground it must be regarded as an artery; and that taking all the circumstances into account, the name venous artery, given to it by the ancients, is its suitable appellation. From the above genesis of the pulmonary artery, and its inauguration into arterial peculiarities of function by means of its association with the bronchial artery, we learn how a vessel that carries venous blood, is enabled to play the part of an artery at its extremities. The power to do this, is communicated to the pulmonary artery by its companion or attendant, the bronchial artery, which latter, arising, as it does, from the aorta, transfers the arterial character to the ultimate branches of the venous artery, by connecting and involving itself therewith. Thus the venous artery derives its proper name from this its parent; wherefore the bronchial artery seems properly to play the artery, but the pulmonary artery to play the vein. Hence the combination and unition of these two characters, presents us once more with the same conclusion; namely, that the pulmonary artery ought preferably to be termed the venous artery.

the lungs, be poured in by the right cavity of the heart, and consequently too much or too little be poured back into the left cavity, the deficiency may be supplied from the common channel of the aorta, or the superabundance be thrown out into the common channel of the intercostals or into the vena azygos (*r*).

(*r*) It is very evident from the varying force and frequency of the pulsations of the heart, as well as from its palpitations, flutterings and spasmodic actions, that that organ sucks in from the veins varying quantities of blood; at one time too much, at another time too little; and it is likewise manifest from the irregularity of the motions and sighs of the lungs, that they also demand different quantities of blood; at one time much, at another time little; particularly after they have been for any length of time under the direction of the will, as during speech, and other daily acts of respiration, when the invitations or desires of the lungs do not correspond with the incitations of the heart. Besides, since the heart and lungs are uniformly discordant in their motions, it is necessary that there should be a regulative and managing artery to reduce these quantities to some kind of equilibrium. Let us take in illustration a single example. During passion, anger, fury, great trials of strength, wrestling, fighting, &c., a large amount of blood is collected in the arteries, the maintenance of bodily strength requiring it, and but little is sent into the veins. This condition is constant with intrepid persons,—with those who are animated with what we term heroic valor. Let us suppose also the contrary case, namely, that the greater part of the blood runs away from the arteries into the veins, as during fear and fright, which condition is usual with timid persons. If either of these opposite conditions occurs, it is evident that the equilibrium between the arterial and venous blood is disturbed; that in the former case but little venous blood flows into the right ventricle of the heart, and consequently but little from the heart into the lungs; in the latter case, that an excessive quantity of venous blood beleaguers the right side of the heart, and threatens to inundate the right auricle; and hence a similar excessive quantity is poured into the lungs, even despite their disinclination to receive it. Now the bronchial artery and vein seem to be brought to bear to equalize these quantities; for if the lungs labor under deficiency, these vessels can then command sufficient blood to supply that deficiency, from the trunk of the aorta or from the intercostal arteries; but if, on the other hand, the lungs labor under excess, the same vessels reject the superabundance, which the cavity of the heart's right auricle refuses to receive, into the vena

IV. The bronchial artery serves to equalize the quality as well as quantity of the venous blood, or that of the right ventricle of the heart, just as the hepatic artery serves to equalize the quality of the venous blood in the liver; for it besprinkles this thick and squalid blood, scraped together, as it is, from so many muddy streams, with blood that has been once lustrated by the lungs, and dilutes and vivifies it, so that it is no longer slow and lazy, but performs its functions with rapidity (*s*). V. By

azygos, or some one of its intercostal roots. Thus by means of their bronchial arteries and veins, the lungs are enabled to equalize these quantities, and so to modify and accommodate their own thirst and hunger, as well as the liberality and profusion of the heart, as that these conditions shall fall into an exact equation. This matter might be illustrated by many similar examples, for there is not a single voluntary action, especially if excited by the emotions of the animal mind, that does not in some measure alter, and produce some degree of discordance in, the equilibration between the arterial and venous blood, the appetencies of the lungs, and the supplies of the heart. Hence were there no regulative artery, the harmony between these viscera would soon be at an end.

(*s*) We treated of the equation of the blood, both with respect to quantity and quality, in the Chapter on the Liver. The equation of the blood with respect to quality appears to form no mean part among the uses of the bronchial artery; for as was shewn above, the venous blood of the heart is sometimes so much adulterated by a number of impure humors, that it is with difficulty it can struggle to the ultimate threads of the reticular web or rete mirabile, but it is viscid, sluggish and sticky, and blocks up its own channels; thus laying the foundation for the frequent abscesses and vomicæ found in the lungs. In order then that this sluggishness may be discussed, and the blood improved in fluidity, an arterial supply is summoned by the bronchial artery, and poured, through anastomoses, into the branches of the pulmonary artery. The aortic or arterial blood is intrinsically and naturally quick and lively, on account of having just undergone purification in the lungs; and hence when poured upon the venous blood, it gives it fluidity, and puts it in spirits; and this, the more rapidly, because the bronchial artery, as shewn above, notes (*o*) and (*p*), constructs the passages, runs on before, and points the way. [The blood of] this artery seems to have something of the same effect as the blood of the coronary artery of the heart. "The bronchial artery," says Winslow,

means of this artery and vein, the lungs concur with the organic machine of the thorax, and produce therewith unanimous actions; for the intercostal arteries and veins, as also the vena azygos, from which these bronchial vessels arise, are the vessels that excite all the respiratory muscles of the body, to forces and actions correspondent and alternate with the internal breathings of the lungs (*t*).

"gives off a small branch to the auricle of the heart on the same side, which branch communicates immediately with the coronary artery" (n. 387). For the blood which circulates through the coronary arteries as well as veins, comes from the right ventricle of the heart and not from the aorta, as shewn in my *Economy of the Animal Kingdom*, in the Treatise on the Blood and the Heart, n. 407, *seqq.*,* and as will be further demonstrated in the next Part of this Work: consequently the coronary blood is altogether venous. The bronchial artery unites with the coronary, in order that it may dilute and vivify this blood also, in like manner as the blood of the pulmonary artery; for it seems to carry it away towards the lungs. It performs a like office when it unites with the vena azygos or any of its branches; respecting its union with which, Winslow says, "In the year 1719, I observed a very plain anastomosis between some branches of the left pulmonary vein, and of one of the œsophageal arteries, which came from the first left intercostal, together with a bronchial artery of the same side. I also observed an anastomosis between the left bronchial artery and the vena azygos" (n. 387). The blood of the azygos and intercostal veins is almost of the same character as the blood of the pulmonary artery: thus the bronchial artery forms anastomoses with these veins of the body, for the same reason for which it forms anastomoses ultimately with the pulmonary artery; namely, for the sake of improving the quality of the blood, and rendering it more fluid.

(*t*) The intercostal arteries and veins, with the vena azygos, are the vessels that supply the intercostal and other respiratory muscles, and the pleura. This needs no demonstration, for the arteries come for the purpose from the trunk of the aorta, and when the work is done, the veins discharge themselves into the vena azygos and vena cava. The only point requiring proof, is, that all the bronchial arteries come

* The passage in the *Economy of the Animal Kingdom* here referred to, does not contain precisely this statement, but seems to imply, that the blood of the coronary arteries and veins arises from all the auricles and ventricles, although from the right ventricle especially. See also n. 403 of that Work.—(*Tr.*)

410. But we must now draw to a conclusion, and in fine contemplate not the details, but the sum and amount of the matter. Respiration is threefold,—natural, voluntary, and mixed. *Natural* respiration prevails, when the lungs from internal causes, and the thorax from external causes, perform a pro-

originally from the intercostals, and thus communicate with those arteries that excite the respiratory muscles; so that as a result, there is a certain correspondence between the external motions, which are chiefly voluntary, and the internal motions of the lungs, which are natural. But the nature of the correspondence is a subject involving detailed treatment. "Sometimes one bronchial artery," says Winslow, "gives off several of the superior intercostals; sometimes several bronchial arteries send off separately the same number of intercostals" (n. 387, and note (*e*), above). See also Heister, n. 385. "The bronchial artery," says Ruysch, "arises from the posterior part of the descending aorta, at about a finger-breadth above the uppermost of the intercostal arteries that arise from the descending aorta," &c. (*Dilucid. Valvul.*, cap. iv., obs. xv.) See also Ruysch's delineation of the origin of this artery, *Ibid.*, fig. 9. With respect to the statement that the bronchial artery sometimes arises from the œsophageal artery, it is to be observed, that the œsophageal artery communicates closely with some one of the intercostals, as Ruysch notices in his *Epist. Anat.* vi. in the description of tab. vii., fig. 3, (inserted also in Mangetus, *Theatr. Anat.*, tab. xci.) where he indicates that "c is the œsophageal artery, arising from the superior intercostal, and which has been hitherto neglected by anatomists." This furnishes another proof of my proposition, that the bronchial artery arises either immediately or mediately from one of the intercostals, and that the bronchial vein terminates in one or another of the intercostal veins, or of the branches of the vena azygos. Thus these proper vessels of the lungs are in constant communication with the external organic mechanism formed by the muscles, so that the external forces are harmonized with the internal. Another question arises, namely, whether or not this artery carries off any impure serosity from the blood going to the intercostal or respiratory muscles; the affirmative to which appears to derive probability from the law, that every vessel supplies such blood as the [parts at its] extremes require and expend; from which we must suppose, that the secretions in the ultimate or intimate constituents of the lungs demand that this artery should bring in a large amount of serosity. But on account of the indeterminate and varying anastomoses between this artery and the intercostals, I dare not do more than regard this use as a probability.

longed series of unanimous reciprocations; and it prevails in one manner during the day, in another manner during the night (*u*). *Voluntary* respiration is various according to the degree of wakefulness enjoyed by the senses, and the animal and rational minds, and according to the forces brought into action in the body, that is to say, according to the bodily exercises; and it may be either pure, or alternating with natural respiration; in which latter case it constitutes *mixed* respiration (*x*). The respirations are irregular, the irregularity depending upon the state of the lungs, or of the palate, the larynx, the trachea, the bronchia, the vesicles, the interlobular cellular tissue, the

(*u*) I term respiration natural, when no voluntary action is superadded to the natural action. This condition obtains as well during the waking state as during sleep; namely, whenever we make no demand upon the inspiratory or intercostal muscles, to cause the external motions to act synchronously with the internal forces, but permit them to proceed of their own accord. For the animation of the brain, wherewith the respiration of the lungs conspires, goes on or alternates as a natural necessity, in order to provide the body with nervous juice. But as soon as we excite the respiratory muscles by the will, movements are generated not consonant with the former movements, and mixed respiration is the result; as in all exercitations of the body, in all emotions of the animal mind, and in all exertions of the rational mind. In these cases, something always occurs that interrupts the constancy of the movements, and resists the natural internal *nisus* of the lungs. But natural respiration during the day is different from natural respiration during the night: in the former instance, the lungs are partially inflated, so as to allow a ready passage to and fro for the air, and to enable them to comply immediately with the slightest intimation of the will: and there is besides a corresponding state of the whole body,—its membranes, tendons, and muscles.

(*x*) The sensitive and active forces of the body may be so much strained, that very little is left to nature; only in fact sufficient to enable her, according to the general state, also superinduced by the will, to resist the voluntary forces, and prevent them from exceeding their limits of power. Thus the voluntary force is conjoined with the natural, in the exact degree in which the voluntary principle abates its efforts; for the force of nature decreases in proportion as the force of the will increases, and *vice versa:* the one acts in a manner against the other; the will, namely, *a posteriori ad priora,* or from without to

pedicles, the rete mirabile, or the air; of the arteries and veins, pulmonary and bronchial, and of the blood and other humors; of the fibres of the pneumonic plexus, and of the animal spirits: depending also upon the state of the thoracic cavity, of the pleura, the mediastinum, the ligament, the diaphragm, the pericardium, the heart, the sternum, the vertebræ, and the ribs; upon the state of the breast, the pectoral muscles, tendons, aponeuroses, blood-vessels and nerves: upon the state of the cerebrum, cerebellum, medulla oblongata and medulla spinalis, with the animations of which the respirations of the lungs accord in their details and stages: and lastly, upon the general condition of the muscular, membranous, sanguineous, and nervous systems. Hence we may have respirations, either even, slow, deep, laborious, weak, harsh, compressed, sharp, hissing, hoarse, stertorous, painful, attended with fits of choking; or uneven, quick, tacit, full, easy, gentle, &c.; and the same [differences] in action, voice, and sound (*y*). These are so many diagnostic and pathognomic signs, revealing in a general manner the ailments and diseases of the body and animal mind; signs which are applicable whether the disease be asthma, continued or periodical, dry or moist, idiopathic or sympathetic, attended with dyspnœa or orthopnœa: or whether it be angina [quinsey], watery, œdematous, catarrhal, schirrous, inflammatory, suppurative, gangrænous, or convulsive: or phthisis, proceeding from ulceration, empyema, abscess, vomica, or crude tubercles: or whether it be peripneumonia, pleuritis, catarrhus suffocans, hectic fever, vertigo, swooning, or phrenitis, &c. In fine, these signs are equally

within; but nature *a priori ad posteriora*, or from within to without. This perpetual renitency and collision are the grounds why the fortunes of human life are limited to so brief a span.

(*y*) We may discern the general condition of the body, from the diversities of both the natural and voluntary respiration. For the same weakness and dullness, or spiritedness and strength, are displayed in the actions of the body, as in the little actions of the trachea and the larynx, that is, in sounds and speech: and although during sickness we seem to be able, by an act of the will, to superadd a certain amount of force to the natural state, yet this only makes the indications more manifest when we return to ordinary respiration. From the above considerations we may conclude, that the diagnosis of diseases may be

important, whether the disease come by defluxion from the brain and animal mind, or proceed by influxion, into the brain and animal mind (z); for the lungs manifest what the brains conceal. But other matters await our attention, and compel us to close the present subject.

founded with equal correctness upon the respiration of the lungs and upon the pulse of the arteries, although it is indeed better to derive it from both.

(z) It is in consequence of the agreement between the animations of the brain and the respirations of the lungs, that we can form a diagnosis of the affections and diseases of the brain, by considering the corresponding manifestations in the lungs. I allude to such affections as apoplexy, hemiplegia, paraplegia, paralysis, epilepsy, catalepsy, delirium, phrenitis, vertigo, swooning, and the like. But of the above influx and reflux, I intend to speak in Part XI., when I come to treat of Diseases, particularly those of the Head or Cerebrum; and in Part XIV., on the Affections and Disorders of the Animus.

CHAPTER V.

THE PLEURA, THE MEDIASTINUM, AND THE PERICARDIUM.

411. HEISTER. "The pleura is a smooth, strong, tense membrane, adhering to the ribs and to the intercostal muscles, and surrounding the whole cavity of the thorax. 1. It consists of two sacs, each of which invests one side of the thorax, and each contains one of the two great lobes of the lungs: the conjunction of these sacs in the middle of the thorax produces the mediastinum. 2. It is composed of two very vascular lamellæ. 3. It has numberless arteries, arising from the intercostal, mammary, and phrenic arteries: veins, arising from the veins corresponding in name to the above arteries, but all of which terminate in the trunk of the vena azygos, and of the superior vena cava: nerves, from the thoracic vertebræ, and from the phrenic nerves; and lymphatics, which run to the thoracic duct. 4. Some writers attribute glands to the pleura, but without good reason. *(Comp. Anat.*, n. 255.) All observations to this effect have been made upon diseased subjects, and derived from morbid conditions; but glands have never been shewn in the pleura, so far as my knowledge extends, in healthy bodies. Hence I am induced to think, that the corpuscules taken for glands, are nothing more than tubercles, the products of disease, which have owed their origin to the stoppage of earthy or viscid matter in the delicate little arteries of these membranes, &c. *(Ibid.*, not. 6.)

412. "The mediastinum is a double membrane, continuous with the pleura, situated under, and firmly connected to, the sternum, and the cartilages of the ribs on the left side, and dividing the cavity of the thorax longitudinally into two unequal parts. Between the two membranes of which this double membrane is composed, there is a cellular interstice of considerable size; 1, in the part nearest the diaphragm, in which inflammations and abscesses sometimes occur; and 2, in the

upper part of the thorax where the thymus gland is situated. *(Ibid.*, n. 253.) Many anatomists of great credit deny the existence of this interstice; pronouncing it altogether imaginary, and contending that it is made by the violence employed in raising the sternum. But for my part, I have found it constantly present, not only in the upper part, but also in the part next the diaphragm; and this, although the sternum be raised as gently, and as little, as possible, just so as to allow the diaphragm to be easily separated from it. With the gentle elevation which I have used, I cannot believe that any change could be made in the parts, or any new and preternatural condition be produced. In a public demonstration which I gave in the year 1730, I shewed a case in which this interstice was so large, that the right membrane of the mediastinum adhered to the middle of the sternum, while the left adhered only to the cartilages of the ribs on the left side. It may be added, that various writers relate instances of abscesses and pus formed therein; and [J. I.] Mayer, a recent author, affirms that he has frequently found it to contain serum. *(Ibid.*, not. 39.) The mediastinum is connected with the pleura, the sternum, the pericardium, and other neighboring parts. It is not situated exactly behind the middle of the sternum, but descends gradually from right to left, whence the right half of the thorax is rendered larger than the left. The arteries and veins of the sternum arise from the mammary and phrenic arteries and veins, but sometimes it has vessels of its own coming directly from the aorta and vena cava, and which when present are termed the mediastinal vessels. Its nerves are small, and come from the phrenic nerves and par vagum. It has also lymphatics, which run to the thoracic duct. The uses of the mediastinum are, I. To divide the thorax longitudinally into two parts, for several important purposes; as, 1. That if one of the lungs be ulcerated, the other may not readily become infected. 2. That pus, water, &c., contained in one cavity of the thorax, may not affect both lungs at once. 3. That when one side of the thorax is wounded, respiration may be still maintained in the other, so that immediate suffocation shall not take place. II. To keep the heart pendulous, and thereby ensure its free motion, particularly when we are lying on our backs. *(Ibid.*, n. 253.)

413. "In examining the sternum, we have to attend to its situation; to its figure, which is like that of a dagger; and to its state during infancy, when it consists of several pieces: also to the number of pieces of which it is composed in adults, varying, namely, from one to three. Its substance is fungoid and spongy. Its upper part is termed the manubrium or handle; and in this there is on each side a cavity for the articulation of the clavicles, furnished with a moveable

cartilage. The middle part of this bone is very narrow, and its lower part is again broad. To the latter is connected a cartilage, called, from its shape, the ensiform or xiphoid cartilage. This is frequently bifurcated, and not seldom ossified throughout. The sternum has seven cavities on each side, for its articulation with the true ribs. (*Ibid.*, n. 135.)

414. "In examining the ribs, called by the Greeks pleuræ, we have to consider their situation; their very different sizes, the middle ribs being the largest, and those above and below them comparatively small; their singular inclination downwards; their connexions, motion, and ligaments; their number, which is twelve on each side; and their division into true and false ribs. The ribs are in part osseous, and in part cartilaginous; the latter anteriorly, the former posteriorly. They are of a curved figure, concave within, convex without, and thereby aid in the peculiar conformation of the cavity of the breast. Each rib consists of a body and two extremities. When we examine the body of a rib, we observe an internal and external surface; an interior and exterior, a superior and inferior labrum or margin; and a groove in the inferior margin of each of the nine or ten upper ribs, which groove lodges the intercostal vessels. Some writers have given each rib a particular name, but they are better distinguished by their number, as first, second, third, &c. In the anterior extremities, the cartilages of the seven true ribs are all joined to the sternum; those of the eighth, ninth, and sometimes of the tenth, are connected to the seventh, and to each other, by means of transverse cartilages. The anterior extremities of the others are loose and free, lying between the muscles of the abdomen and the diaphragm. On the posterior extremities of most of the ribs, there are two capitula or little heads, which are strongly joined to the dorsal vertebræ, forming moveable articulations; and beside the anterior capitulum we observe a rough tubercle, with a ligament inserted into it, but this capitulum is wanting in the two or three lower ribs." (*Ibid.*, n. 131—134.)

415. WINSLOW. "The pleura is a membrane which adheres very closely to the internal surface of the ribs, sternum, intercostal, subcostal, and sterno-costal muscles, and to the convex side of the diaphragm. It is of a very firm texture, and plentifully stored with blood-vessels and nerves, in both of which respects it resembles the peritonæum, being like it composed of a true membranous lamina, which forms its cavity, and of a cellular tissue, which forms its convexity, and which is a production or continuation of the lamina. The cellular portion goes quite round the inner surface of the thorax, but the membranous portion is disposed in a different manner. Each side

of the thorax has its particular pleura. The two pleuræ are entirely distinct from each other; and resemble two large bladders, put together side by side in the cavity of the chest, in such a manner, as by their apposition between the vertebræ and sternum, to form a duplicature or septum; their other sides adhering to the ribs and diaphragm. This duplicature of the pleuræ is termed the mediastinum. The two laminæ of which it is made up, are closely united together at the sternum and vertebræ: but in the middle, and towards the anterior inferior part, they are separated by the pericardium and heart: a little more posteriorly they are parted in a tubular form by the œsophagus, to which they serve as a covering: and in the most posterior part, a triangular space is left between them and the vertebræ, from the top to the bottom, which is filled chiefly by the aorta. In front of the heart, from the pericardium to the sternum, the two laminæ adhere very closely, and there the mediastinum is transparent, except for a small space at the upper part, where the thymus gland is situated: so that in this place, there is naturally no interstice or particular cavity. Any apparent separation there may be, is owing entirely to the common method of raising the sternum: as was plainly demonstrated by Bartholin. . . . I shall have occasion in another place to mention Eustachius' Tables, where this separation is erroneously represented as a natural condition of the parts. . . . In the year 1715 I demonstrated to the Royal Academy of Sciences, that the mediastinum inclines from above downward towards the left side: and that if the middle of the sternum be penetrated by a sharp instrument before opening the chest, there will be found to be almost the breadth of a finger between the sternum and the mediastinum: provided the sternum be kept in its natural situation, and the cartilages of the ribs be cut off at the distance of an inch from it on each side. From all this we see, not only that the thorax is divided into two cavities, entirely separated from each other by a middle septum; but also that the right cavity is greater than the left on account of the obliquity of the septum. . . . The cellular portion of the pleura connects the membranous portion to the sternum, ribs, and muscles; to the diaphragm, pericardium, thymus gland, and vessels; and in fine to whatever lies near the convex side of the membranous portion. It likewise insinuates itself between the laminæ of the duplicature of which the mediastinum is formed, and unites them together. It even penetrates the muscles, and communicates with the cellular substance in their interstices, all the way to the external adipose membrane on the convex side of the thorax. In these respects, the pleura resembles the peritonæum. The surface which looks towards the cavities of the breast, is continually moistened by a lymphatic serosity, which oozes

insensibly from the pores of the membranous portion. . . . The arteries and veins of the pleura are chiefly ramifications of the intercostals: these ramifications are exceedingly numerous, and for the most part very small. The internal mammary and phrenic vessels likewise give some branches, which communicate very freely with those that come from the intercostals. The mediastinum has its own particular vessels, the mediastinal arteries and veins, which are commonly branches of the subclavian vessels. The internal mammary vessels supply its anterior branches, the phrenic, its inferior, and the intercostal and œsophageal, its posterior. Its nerves come from the costal and dorsal or true intercostal nerves. Near the vertebræ they communicate with the great sympathetic nerves, improperly called the intercostal nerves, but only sparingly with the middle sympathetic, or those of the eighth pair. (*Exp. Anat.*, *Tr. de la Poitrine*, n. 25—34.) The portions of the pleura which adhere immediately to the ribs, may be regarded as the periosteum of their inner sides. The connexion of the pleura with the ribs, keeps it stretched, and prevents it from slipping or sliding: it also renders it extremely sensitive to the least separation caused by coagulated lymph or accumulated blood; the nervous filaments in this case being extraordinarily compressed in inspiration by the expansion of the intercostal muscles. (*Ibid.*, n. 36.) Uses:—The pleura serves, in general, as an inner integument to the cavity of the thorax. The mediastinum cuts off all communication between the two cavities, and keeps one lung from pressing the other when we lie on either side. It likewise forms receptacles for the heart, pericardium, œsophagus, &c.; and is continued over the lungs." (*Ibid.*, n. 35.)

THE PERICARDIUM.

416. HEISTER. "The pericardium is a membranous bag, loosely surrounding the heart, and situated in the middle and lower part of the thorax, between the two lungs. It is of a conoid figure, answering to that of the heart, and almost triangular. Its size is accommodated to the purpose it is intended to serve,—of containing the heart. It is connected with the mediastinum, the diaphragm, and the great or common vessels of the heart; and by these connexions, it, together with the heart, is sustained in its place. In most animals, however, the pericardium is not joined to the diaphragm. It is composed of two membranes, the external of which it has in common with the mediastinum and the pleura: the internal membrane is proper to the pericardium; and is lubricous, and continuous with the coats of the large vessels; and when held up to the light, we sometimes see in it a great number of little foramina or pores. The arteries and veins of the pericardium are derived from the mediastinal and phrenic vessels. Its nerves are from the phrenic nerves. Its lymphatics run to the thoracic duct. . . . The liquor pericardii is a liquid similar to the washings of meat, and which is found in the pericardium, generally in small quantities; it seems to be of use for lubricating the heart, and facilitating the free and continual motion required of that organ. This needful liquid is collected in the bag of the pericardium, in order that there may always be a proper supply of it. Many writers maintain that it comes from certain glands, which, they will have it, exist either in the pericardium, or in the heart itself; but as these glands cannot be demonstrated, I am rather inclined to suppose that this liquid is expressed from the heart and auricles themselves, during their systole: which is confirmed by an observation which Bartholin made in a case of wound of the pericardium, *(Anat. Reform.*, cap. de Pericardio,) and by an experiment of Thebesius *(Dissert. de circ. sang. in corde)*: and I think it more probable that it is reabsorbed, than secreted, by the pores of the pericardium; though this is stoutly denied by some authors. In hectic cases, I have sometimes observed an adhesion of the pericardium to the heart: and instances are recorded in which the pericardium was wholly wanting." *(Comp. Anat.*, n. 260.)

417. WINSLOW. "The heart with all the parts belonging to it, is enclosed in a membranous capsule called pericardium, which is of a somewhat conical figure, and much larger than the heart. It is not fixed to the base of the heart, but above the auricles round the great veins, before they send off their ramifications, and at the trunks of the

large arteries, before they make their divisions. The pericardium is made up of three laminæ, the middle and principal of which is composed of a very firm tissue of tendinous filaments closely interwoven and crossing in different directions. The internal lamina seems to be a continuation of the outer coat of the heart, auricles and great vessels. The trunks of the aorta and pulmonary artery have one common coat which contains them both as in a sheath, and is lined on the inside by a cellular tissue that is chiefly accumulated in the spaces where the trunks, and the sides of the sheath, come into mutual apposition and contiguity. Only a small portion of the inferior vena cava is contained within the pericardium. The middle lamina is what particularly forms the bag of the pericardium. This bag is not simply conical: its apex is very round, and its base has a particular elongation, like a little head, which surrounds the great vessels as amply as the other portion surrounds the heart. The pericardium is closely connected to the diaphragm, not at the apex, but exactly at the place which answers to the flat or lower side of the heart: it is so strongly adherent at this spot, that it is very difficult to separate it by dissection. The adhesion extends no further than the limited portion, which is in some measure triangular, answering to the lower side of the heart. The rest of the bag lies upon the diaphragm without any adhesion. The external lamina, or more properly speaking the common covering, is formed by the duplicature of the mediastinum. It is connected to the proper bag of the pericardium by the cellular tissue of that duplicature; but leaves it where the pericardium adheres to the diaphragm, on the upper surface of which it is spread, forming a continuation of the pleura. The internal lamina is perforated by an immense number of imperceptible holes, through which a serous humor continually transudes, in the same manner as from the internal surface of the peritonæum. This humor gradually collects after death, forming what is called the liquor pericardii, a certain quantity of which is generally found in recent subjects. Sometimes it is of a reddish color, which may be owing to a transudation of blood through the fine membrane of the auricles." (*Exp. Anat.*, *Tr. de la Poitrine*, n. 78—83.)

418. Malpighi. "The pericardium is a gland, or glandular body, and constantly secretes a peculiar humor. It is covered internally by a thick, smooth, and shining membrane, which is very different from its external coat. Under this membrane lie certain fleshy fibres, running circularly, or from the base to the apex; and also certain vessels and nerves: and when it is compressed, an almost innumerable quantity of minute drops gush from particular orifices on its internal surface. I have found this a constant phenomenon, both in the human subject, in

birds, oxen, and all the quadrupeds I have had an opportunity of examining. The excreted humor, particularly that from the ox, evaporates by gentle heat, leaving only a very small residuum. . . . The pericardium when compressed will often yield little drops of this liquid for as long a time as two days after death. . . . I will now mention certain singular appearances which I witnessed in a *post mortem* examination of the body of a boy. In this case, the pericardium throughout was about half an inch in thickness, excepting at the base, near its connexion with the heart, where it was full an inch thick. Exteriorly it was surrounded by a thick and irregular glandular mass which was parted into lobules. The interstices between the lobules were filled with little mucous cakes of coagulated humor, which in some parts was of a yellowish color; in some parts a fluid of corresponding color, was confined [in the interstices]. Some few of the round glandular bodies contained a cavity, filled with the matters just mentioned. This glandular mass did not appear to be at all natural either in its structure or substance, but resembled a congeries of glands, hypertrophied by disease, and degenerated in character. Underneath it ran certain fleshy fibres of a singular whiteness, and which commenced from the base, and wound about in various directions. Blood-vessels also were found ramifying in the same situation; and next to them came the internal coat, supplied with a reticular interlacement of very thick blood-vessels, which were most abundant on the internal surface. The concave side of this coat or membrane had a kind of mucous crust or pellicle closely adherent to it, very similar to the little cakes already mentioned, and of a pale straw color, the whole surface being covered by it, and it could not be removed without force. When this mucous substance was held over the fire in a spoon, instead of liquefying, it thickened into something like coagulated serum. And after its removal, when the internal membrane of the pericardium was denuded and compressed, as usual a humor came out in drops from an almost innumerable quantity of orifices placed in parallel rows. The cavity of the pericardium was completely destitute of fluid, and only contained the heart, which was altogether covered with an external coat, very similar to the mucous crust noticed above, and which adhered so firmly, that when pulled off, the delicate membrane of the heart was lacerated, and a bloody serum issued from it when slightly scraped. The whole mass of the heart was found to be wasted and degenerated.

"We may infer from this singular case, that the secretion of the humor found in the pericardium was carried on by the surrounding glands. . . . The pericardium, then, is designed for the secretion of a particular serum; which serum is always observed in both living and

dead subjects. It is generally pellucid, though sometimes it has a reddish tinge, particularly in animals, and sometimes it consists of a turbid gray-colored fluid, with a salt taste. Four ounces of it exposed upon the fire in a pan, evaporated in less than half an hour, without any remarkable or violent ebullition, leaving a fine reddish residuum, which had a smell like boiled meat. In more than one instance I found it abnormally increased in quantity, and in one subject, (Laurentius Zagonius,) I remember observing above four pounds of it, of a yellowish color, and eight pounds of a similar humor in the abdomen: the viscera and vessels in this case were clogged with black and grumous blood, like what we always find in brutes after aquafortis is injected into the veins. In other morbid states, this humor is altogether wanting. I observed this in another subject, (Joan. Andreas Landinus,) in which the pericardium was perfectly empty of fluid, and so firmly glued to the heart, that when torn off, it brought away with it a piece of the substance of the heart. In this instance all the viscera were studded with miliary glands, full of tartar. . . . I take this opportunity of stating, that when the above humor is in a morbid condition, the rhythm of the heart's motion is destroyed; and lately, in examining the body of a patient, who had had vibration and tension of pulse, and a sensation of distress at the heart, two pounds of turbid fluid were found in the pericardium; the right ventricle was large enough to contain the whole of the other side of the heart; the aorta was three finger-breadths across, had squamous pieces of bone growing on its internal surface, and was itself very much solidified." *(Opera Posthuma—De Structurâ Glandularum Conglobatarum,* &c., p. 146—148. Amstelod., 1598.)

419. Lancisi. "The middle coat of the pericardium is thick and muscular. *(De Motu Cordis et Aneurysmatibus,* lib. i., sec. i., cap. iii., prop. v.) The fibres of the pericardium are inwoven with the inferior vena cava, at the place where it perforates the diaphragm; . . . so that the two together form a circular muscle in that situation. . . . The external coat of the pericardium is continuous with the outermost coat of the lungs and of the mediastinum: the middle or muscular coat goes off into sheaths for the pulmonary vessels: the internal coat, which has all the appearance of being nervous and tendinous, is reversed, and doubled back towards the heart, so as to invest those portions of the great vessels that are contained within the pericardium; and it is also spread and extended, so as to cover the coronary arteries, and the whole surface of the heart. *(Ibid.,* prop. vi.) The pericardium forms a particular capsule that covers and ties down the divisions of the three pulmonary vessels, . . . and is continued all the way to the external

surface of the lungs. *(Ibid.*, enunciatio prop. vii.) On the anterior surface, the pericardium will be found to be attached to the two great arteries, and to ascend upon the last segment of the trachea, so as to cover at the same time the bronchial tubes : on the posterior surface it will be observed to be spread under the arch caused by the divarication of the bronchia, and to be firmly connected to them, and to the heads of the great veins. And if we dissect out the surface of the pericardium in the direction of the lungs, . . . and remove a portion of the vesicular substance of the latter, it will be seen that all the pulmonary vessels, both aëriferous and sanguineous, are beautifully environed with the pericardium. *(Ibid.*, prop. vii.) In all the subjects which I have examined for the purpose, [both healthy and the reverse,] I have found a number of glands upon the pericardium, . . . the chief part of which are formed to secrete a lymph, and to supply it, by particular ducts, to the pericardium. *(Ibid.*, cap. v., prop. xvii.) These glands are imbedded in fat." *(Ibid.*, prop. xviii.) Our Author describes also the situation, number, magnitude, &c., of these glands. *(Ibid.*, prop. xviii. xix.)

ANALYSIS.

420. If we pursue the pleura by sight through its circumflexions, in truth we are carried about through labyrinthine windings and absolute mazes, and only rest at last either in the innermost parts of the lungs or in the innermost parts of the heart.* Take any point of the membrane that you please, and trace the outline that it makes, and the circle that it describes: in the first instance you will be conducted from the concave circumference of the thorax to the mediastinum, where the pleura forms a knot, and whence it returns into its gyre (*a*):

(*a*) It is evident from the anatomical experience prefixed to this Chapter, that the pleuræ, coming by circumvolution on both sides from the vertebræ, coalesce into a broad duplicature behind the sternum or pectoral shield, and then pass backwards and forwards transversely between the lungs, dividing the cavity of the thorax into two chambers. This duplicature or coalition is termed mediastinum, and in reality is nothing more than the pleura, but which here constitutes a particular septum between the two great lobes of the lungs. But in order that the reader may not be misled by the circles which we are now drawing, it will be better to repeat the description of the mediastinum given by our Authors. "The mediastinum," says Heister, "is a double membrane, continuous with the pleura, situated under, and firmly connected to, the sternum, and the cartilages of the ribs on the left side, and dividing the cavity of the thorax longitudinally into two unequal parts" (n. 412). And Winslow says, "Each side of the thorax has its par-

* It is obvious that Swedenborg includes under the terms pleura, peritonæum, &c., not only the smooth surface and subjacent cellular layer usually admitted to constitute those membranes, but also the whole of the cellular tissue continued from that layer into the interiors of the viscera, the muscles, &c.—(*Tr.*)

then you will find that it turns off, with an ascending movement, to the concavities and axes of the lungs, and effusing itself round the surfaces of their lobes, passes up and down upon those surfaces, and constructs them (*b*): in the next place, that it penetrates to the intimate recesses of the lungs, by a continual series of trabecular cellular bands, perchance by unnoticed forms running in an everlasting circle (*c*). Yet it does

ticular pleura. The two pleuræ are entirely distinct from each other; and resemble two large bladders, put together side by side in the cavity of the chest, in such a manner, as by their apposition between the vertebræ and sternum, to form a duplicature or septum. . . . This duplicature of the pleuræ is termed the mediastinum" (n. 415).

(*b*) I believe it is well agreed, that the pleura is continued over the external surface of the lungs. "It [the mediastinal portion of the pleura]," says Winslow, ". . . is continued over the lungs" (n. 415). The particular channel by which this continuity is effected, will be explained presently. The pleura, therefore, performs its second circuit around the lungs, the first being around the cavity of the thorax; so that whereas in the former instance it constitutes a concave surface, in the latter it constitutes a convex surface. Now this can only be, by a continuation of the sphere or circle in a kind of spire,—by a circumflexion of a spiral kind, of such a character, that the exterior circle produces the interior circle by continuity. From this surface, taking the way to the pericardium, the pleura effects a return to the exterior surface; for the outer coat of the pericardium is continuous not only with the medastinum but also with the surface of the lungs. Afterwards it leaves the pericardium in the diaphragm, and unites with the pleura; and thus runs a second time through the same gyre.

(*c*) Respecting the production and continuation of the cellular tissue from the surface of the lungs all the way to the aëriferous vesicles, see the Chapter on the Lungs, and the subsequent portion of the present Chapter. The statement that this continuation towards the interiors takes place by a particular form analogous to a kind of perpetual circle, is only assumed conjecturally; for we have hitherto had no opportunity of investigating the fluxion wherewith these cellular interstices ascend from the centres to the circumference, and descend from the circumference to the centres. Meanwhile it cannot be doubted, that all things have their fluxion according to the most regular laws. But we leave the point for future investigation. "The pellicles," says Winslow, "which compose it [the cellular substance] are . . . disposed

not tarry even here, but instantly goes out around the pulmonary arteries and veins in the form of a continuous capsule, along the vascular and tracheal causeways (*d*), where meeting itself, it enters a new field, and runs forth around the second or lesser pleura, which embraces, demarcates, limits, and connects, the heart and its auricles and vessels, and is termed the pericardium (*e*). After this, it runs out by three ways; by the first, in conjunction with the mediastinum, it returns to the very starting-places from which its race began, that is to say, to the general thoracic pleura: by the second, it runs to the ultimate goals of the thorax, in the diaphragm, in order to bend its course therefrom to the peritonæum, and to the circus of the inferior region: by the third and innermost, it passes into the very parenchyma of the heart, where it does not make an end, until it reaches the heart's innermost

there [around the vessels] in a more regular manner, and more longitudinally than in other places" (n. 387).

(*d*) Lancisi was the first who discovered, that a particular capsule continued from the pericardium, invests all the vessels of the lungs, as well the air-vessels or bronchia as the blood-vessels, and also the nerves, and does not terminate until it arrives in the intimate recesses of the lungs. This capsule is described by the above-mentioned Author in his [posthumous] Work, *De Motu Cordis et Aneurysmatibus*, from which we have given certain extracts bearing upon the subject (n. 419); it is also mentioned by Heister (n. 385); and Winslow intimates that it is identical with the cellular substance (n. 387). Now inasmuch as this tissue goes to the very surface of the lungs, and adheres thereto, it follows, that it not only passes towards the innermost parts, by the cells, exactly as by cross-beams and little bridges, but that it also passes from the innermost parts, by the same membranous cells, along the arteries and veins, to the pericardium. But this circle, thus running from the pleura and the surface of the lungs to the innermost parts, from these again to the pericardium, and from this to the pleura, is in fact a transcendent circle, since it proceeds from the outermost to the innermost, that is, from the last things to the first, and afterwards from the first to the last.

(*e*) On this subject, see the last paragraphs of the present Chapter, where we treat of the Pericardium, and the next Chapter, where we treat of the Thymus Gland.

substances (*f*),—those substances from which every end in the body takes its beginning. Such then are the labyrinthine meanders and reflexions of the pleura, gyre within gyre. The

(*f*) The pericardium is a contexture and convolution of three distinct laminæ or membranes,—an external, a middle, and an internal. The external membrane is derived from the mediastinum, and from the surface of the lungs. "The pericardium," says Lancisi, ". . . covers and ties down the divisions of the three pulmonary vessels, . . . and is continued all the way to the external surface of the lungs" (n. 419). The same membrane is continuous with the mediastinum, and leaves the pericardium where it is in contact with the diaphragm, uniting with the common pleura of the thoracic cavity; according to the following from Winslow; "The external lamina [of the pericardium]," says he, "or more properly speaking the common covering, is formed by the duplicature of the mediastinum. It is connected to the proper bag of the pericardium by the cellular tissue of that duplicature; but leaves it where the pericardium adheres to the diaphragm, on the upper surface of which it is spread, forming a continuation of the pleura" (n. 417). The middle lamina of the pericardium, (which, according to Lancisi, "goes off into sheaths for the pulmonary vessels" (n. 419), and properly is a continuation of the cellular substance,) adheres to the diaphragm, and bends its course to the peritonæum. Thus Winslow says, "The pericardium is closely connected to the diaphragm: . . . it is so strongly adherent, . . . that it is very difficult to separate it by dissection" (n. 417). The internal lamina is reflected towards the surface of the heart. On this subject again, Winslow says, "The internal lamina seems to be a continuation of the outer coat of the heart, auricles, &c." (n. 417). And Lancisi remarks, "That the internal coat . . . is reversed, and doubled back towards the heart, so as to invest those portions of the great vessels that are contained within the pericardium; and it is also spread and extended, so as to cover the coronary arteries, and the whole surface of the heart" (n. 419). The same author shews in another passage,[x] that the internal coat divides and ramifies all the way to the innermost parts of the heart, which circumstance we shall have occasion to notice further in the Part on the Heart. Seeing then that we cannot trace the pleura through its entire course without arriving at the mediastinum, nor the mediastinum without arriving at the pericardium, I have deemed it expedient to treat of all these three parts together: otherwise the reader's vision would in all probability be abruptly terminated at the very threshold or first division of the subject, and he would have no opportunity of resuming and extending it

entrance to the maze is easy; but except we keep firm hold of the thread of experience, and unwind and wind it, we shall never escape again, unless in the manner of Dædalus and his son we fly out through the air, that is, through empty conjectures.

421. I. The pleura is the common and proper integument, limit, and bond, of the cavity of the thorax; it separates the outer wall and breast-work, osseous and muscular, from the chamber within, and the viscera inhabiting it, namely, the heart and lungs; and by means of the mediastinum it divides this chamber into two halls or galleries. It then passes by the nearest ways to both the lungs, and mounting them, climbs to their circumference, describing and constructing it. From the circumference, as from an area intersected by innumerable paths, it passes to the vesicles, vascular networks, and interlobular cells; in fine, deep into the very centres of the lungs. Thus the pleura, as a uniting medium, binds and connects the outermost constituents of the thorax to the innermost; and forms passages of such uninterrupted continuity between the two, that the external forces and actions, namely, of the muscles of the thorax, flow in all the way to the intimate and multiple lungs, that is, to the vesicles; and excite their forces into respiratory actions: and this, with so much harmony and correspondence, that not the least particular can be involved in any action designed in the thorax, without the vesicular lung being made conscious of it, and exercising exactly analogous pneumonic actions (*g*). The following experimental facts indi-

until the next Chapter. Thus, in order to present the subject in its fulness, I have determined to bring all these pleuræ under one view.

(*g*) These particulars are proved by the statements immediately following them. We need here only intimate, that motion and connexion of parts are exact correlatives; for substances, and their organic connexions, are constructed and formed for no other end than for the fluxions and determinations of active forces. The determination of substances involves a corresponding determination of accidents and motions, which run along substances as their appointed little bridges, and this exactly according to the forms laid down; as we may clearly observe to be the case in the organs of the external and internal senses: hence when these forms are injured or disturbed, actions and effects

cate and declare that these thoracic actions flow in by the way of the pleura to the lungs, although the converse is not the case, that the pulmonic actions flow out by this way to the thorax (*h*): namely, 1. The pleura adheres closely to the ribs and sternum, in the manner of a periosteum; likewise to the intracostal muscles, and to the triangulares sterni (*i*); and it is

result corresponding to the lesion. This is the reason why I undertake the task of investigating the organic forms of the body, anatomically, physically, and philosophically.

(*h*) The thorax exerts an action upon the lungs, and not the lungs upon the thorax, but upon the bronchia, the trachea, and the air, as I shall shew in the Epilogue to this Part. I will here confine myself to stating, that after the lungs are opened, all action is inverted, that is, proceeds from without to within. But so long as we lived under the auspices of nature, in the mother's womb, the action was determined from within to without. Hence at this time nature, by [her] determinations, laid down these paths, and so prepared the organic forms, that when the hinge was turned, it would be easy to determine the axes of these wheels even into inverse motions.

(*i*) The cavity of the thorax is opened by means of the muscles and ribs. See the Chapter on the Lungs. Thus if the pleura is so closely connected to these parts that it undergoes a change corresponding to every the least elevation of the ribs, it will follow, that by means of the pleura as a common bond, a similar action must be communicated to the lungs; as we fully proved to be the case in the last Chapter. Winslow shews that its connexion with the ribs and sternum is of this character. "The pleura," says he, "is a membrane which adheres very closely to the internal surface of the ribs, sternum, intercostal, sub-costal, and sterno-costal muscles, and to the convex side of the diaphragm. . . . The cellular portion of the pleura connects the membranous portion to the sternum, &c. . . . and in fine to whatever lies near the convex side of the membranous portion. . . . The portions of the pleura which adhere immediately to the ribs, may be regarded as the periosteum of their inner sides. The connexion of the pleura with the ribs, keeps it stretched, and prevents it from slipping or sliding: it also renders it extremely sensitive to the least separation caused by coagulated lymph or accumulated blood; the nervous filaments in this case being extraordinarily compressed in inspiration, by the expansion of the intercostal muscles" (n. 415). The description of the mediastinum clearly shews the manner in which the pleura adheres to the

united to the dorsal nerves themselves and intercostal vessels, as they are about to enter the moving fibres of the muscles (*k*). 2. The pleura is spread upon the plane of the diaphragm; and connected to the concave part of the lungs by the dorsal ligament (*l*); and to the last ring of the trachea, and to the bronchia, where it forms the mediastinum (*m*); and it is expanded

sternum. Thus every change arising from motion, runs through the rounds and circles of the pleura all the way to the mediastinum, and is concentrated in the two laminæ thereof.

(*k*) The costal arteries, veins, and nerves run along the ribs in a groove extending from the vertebræ nearly to the sternum, that is, nearly to the extremities of the ribs, and in this course are tightly bound down by the pleura. Hence when any motion of elevation or depression occurs, the action descends into all points of the nerves; as shewn by the last observation cited from Winslow (*i*). Respecting the manner in which the nerves run along the ribs, see Vieussens, *Neurogr. Univ.*, lib. iii., cap. vii., and tab. xxvii. "The vena azygos and its branches," says Verheyen, "and the intercostal arteries and nerves, lie in a duplicature of the pleura." (*Corp. Hum. Anat.*, tract. iii., cap. v.) Now since the pleural membrane covers the nerves and vessels that enter the respiratory, or infra-costal, intra-costal, and supra-costal muscles, and give them their power of acting; and since the pleura at the same time acts upon the muscles, and the muscles act back upon the pleura,—it follows that there is a reciprocal action and reaction, consequently a perpetual correspondence of action: so that every particular involved in each action must be communicated to the pleura. We now proceed to the action of the pleura upon the lungs.

(*l*) Respecting this ligament, see Winslow, n. 387; and respecting its influx into, and its influence upon, the lungs, see the last Chapter, *passim*.

(*m*) We all know that the trachea descends into the thorax between the two pleuræ, that is to say, through the mediastinum; likewise that the pleura, beside the bifurcation of the trachea into the bronchia, is identified with the mediastinum, near the great pulmonary vessels of the heart, and not only spreads forth from this spot over the surface, but also borrowing a new tunic from the pericardium, enters the lungs in the form of a capsule. "On the anterior surface," says Lancisi, "the pericardium will be found to be attached to the two great arteries, and to ascend upon the last segment of the trachea, so as to cover at the same time the bronchial tubes: on the posterior surface it will be

therefrom over the universal surface of the lungs. 3. This surface is continuous, by means of the cellular tissue, with the aëriferous or spiratory vesicles (*n*), which the pleura again

observed to be spread under the arch caused by the divarication of the bronchia, and to be firmly connected to them, and to the heads of the great veins" (n. 419). Let us now see how every action of the pleura pours forth into the lungs, and is ultimately concentrated in their innermost parts, about the vesicles. The ligaments mentioned in the text, run exactly from the boundaries where the two pleuræ coalesce, that is to say, from the neighborhood of the vertebræ, and from the mediastinum; so that the action imprinted upon the pleura by the ribs and muscles, converges on both sides to those boundaries. Furthermore, they pass exactly into that which is the polar and by continuity the axillary part of the lungs; namely, into their concave surface, where the bronchia and pulmonary vessels enter them: so that the action is thrown from the external circumference to the very axis, from which there is an uninterrupted path to every vesicle. From these boundaries, the same sort of action flows also over the whole surface of the lungs, at the same time that it flows, as we have just shewn, into their intimate substance. The forces which spread themselves from the same points around the surface, and go inwards along the axis, cannot fail to be increased in their course, and to be indefinitely multiplied, and at length to meet in all the centres. From these in an instant proceeds the effect which constitutes respiration, and which is precisely compliant with the action of the thorax; as was laid down in the Chapter on the Lungs. I shall not now dwell upon the immediate action of the diaphragm upon this concave part of the lungs, further than to say that it is a general action, exactly corresponding to the collected particular actions. In addition to this, the pleura acts in some measure, by means of the diaphragm particularly, upon the nerves that it covers, I mean, upon the great sympathetic or intercostal nerves, and upon the par vagum, the fibres of which constitute the pulmonary plexus; likewise upon the plexus at the threshold or entrance to the bronchia. Thus there is not a single nervous filament, not a single vascular twig, and not a single membranous thread, that the action of the pleura does not invade in a multiplicity of ways; thereby exciting the intimate spirit of the nerves and the blood of the vessels to compliance with the motion of the thorax.

(*n*) We observed in the Chapter on the Lungs, that air blown into the interstices or cellular tissue, passes rapidly to the surface of the lungs, inflating it, and causing it to swell, before the other parts, so

reaches by an opposite course, following the fluxion of the bronchia, and of the blood-vessels and nerves; so that while it is going upwards, it sees itself coming downwards (*o*), and thus fastens these very centres, the vesicles, in a tight and complex knot, and brings forth in effect therein, whatever the cause in the outermost commands, with any even the smallest intimation or action.

422. II. The pleura, carried round in spiral and natural arches, not merely transfers and infuses the actions of the muscular chest into all points of the lungs, but it also produces and effuses the sphere and essential forces of this activity into the peritonæum, and by the assistance of that membrane, into the secluded viscera of the cavern of the abdomen; and not alone into their external or limitaneous coverings, but also, as in the case of the lungs, into their most secret follicles and depths (*p*).

that the surface appears studded all over with air vesicles: also that the lymphatics of the lungs imbibe their lymph at the surface from the juice arriving thither: in a word, that the cellular tissue reaches uninterruptedly from the surface to the vesicles, and *vice versa;* just as we found to be the case in the liver, the spleen, the kidneys, and the other viscera of the abdomen. The effect of which we are speaking is the result of this uninterrupted continuity. "It [the cellular tissue] is dispersed" says Winslow, "through every part of the lungs, and forms cellular or spongy sheaths which surround the ramifications of the bronchia and blood-vessels, and is afterwards spread over the outer surface of each lung, where it forms a kind of fine cellular coat, joined to the general covering of that viscus" (n. 387).

(*o*) This will be found to result as a consequence from the particulars laid down above, if duly weighed and examined. For the pleura, as observed before, ascends around the bronchia and pulmonary arteries and veins, to the surface of the lungs; and enters them also at the same place by its companion, the pericardium. All communication between the surface and the intimate substances of the lungs, is ultimately determined towards the pericardium, where it [the pleura] may be said to go out, and continue its course towards the heart. Thus, as it goes upwards, it sees itself coming downwards. These considerations may enable us to understand the communication of the lungs with the pericardium, although not the influx of motion.

(*p*) We treated of the extension of the respiratory action by means of the diaphragm and peritonæum, in our analyses of the several vis-

But the pleura flows and penetrates with the active breath of the lungs into the intimate constituents of those viscera, not only by the way of the peritonæum, which is an external way, but also by the way of the nerves, arteries, and veins, which is an internal way,—the way of the brain and heart themselves. Thus the external respiratory forces of the lungs, and the internal animatory forces of the brain, united with the respiratory, meet in the centres of all the viscera, and rouse every part, however minute or imperceptible, to particular operations corresponding to its structure and nature. But it behoves us to follow and unwind the thread of experience,—that thread which is the true guidance of Pallas and the Muses,—lest we lose ourselves, and fall an easy prey to error, in these labyrinths of nature. For the purpose of furthering the above influx, the diaphragm or middle septum is extended and interposed between the two chambers, being constituted on one side by the pleura, on the other side by the peritonæum. The lungs lie with their depressed portion upon this septum; the pectoral breast-plate, the ensiform cartilage, and the falciform ribs, are implicated with it: the muscles of both regions are in a manner connected and continued to it: through it, the œsophagus, sur-

cera of the abdomen; and we shewed that the peritonæum and the diaphragm enter all the viscera environed by them, by particular ligaments; from which ligaments they expand over the surfaces of the viscera, and so produce their common coat: and further, that by means of capsules or sheaths, in which they enclose both the proper and common vessels of the viscus, they penetrate all the way to the intimate glands or vesicles; just as the pleura penetrates to those of the lungs. But the appliances and instrumental causes by which the influxion of the lungs, or what amounts to the same thing, of their respiration, is communicated to the peritonæum, will furnish a subject for inquiry in the Chapter on the Diaphragm; since it is the diaphragm by which this end is attained. In this place I will do no more than enumerate the general modes of communication; and for this reason, I decline to specify further their integral series, and simply dwell upon those parts thereof which the pleura itself contributes to the general end, before its conjunction with the diaphragm. That the pleura propagates the activities of the lungs to the peritonæum, see Part I. n. 320, 324.

rounded by both the pleuræ, is transmitted as an axis to the stomach: through it also pass the two sympathetic nerves, that enter, construct, and govern the innermost pores of the viscera of the abdomen; likewise the inferior vena cava, and the aorta, the great parent of the arteries. The respiratory action of the lungs is introduced through its open gates, from without and from within, into the viscera of the peritonæum. We are now touching, however, upon the immediate and proper offices of the transverse septum (*q*). But the proper offices of the pleura are the following. It encases and invests the œsophagus by means of the mediastinum, and pours around it the pulmonic motion (*r*); likewise its stomachic plexus (*s*): and this, in order that the œso-

(*q*) On these subjects see the Chapter on the Diaphragm, where the particulars of the passage of the above parts through that septum, and of their connexion with it, may be confirmed by a reference to the anatomical experience that will there be premised. The diaphragm is a continuation not only of the pleura but also of the peritonæum; it is in fact constituted of both; but it conjoins these two common sheaths and bonds by muscles and filaments proper to itself; and thus brings the action of the one into complete harmony with the action of the other.

(*r*) Winslow informs us, that the œsophagus opens for itself a way towards the stomach between the two coats of the pleura, that is, through the mediastinum, and is surrounded by a coat borrowed from the latter. "The two laminæ," says he, "of which it [the mediastinum] is made up . . . in the middle and towards the anterior inferior part, . . . are separated by the pericardium and heart. A little more posteriorly they are parted in a tubular form by the œsophagus, to which they serve as a covering" (n. 415). Again he says, "The first coat [of the œsophagus], in the thorax, is formed only by the duplicature of the posterior part of the mediastinum; it is wanting above the thorax, in the neck" (n. 76). Now since this coat sheathes the nerves of the par vagum, or the stomachic plexus, and likewise communicates with the interior coats of the œsophagus, therefore it follows, that every vibration of the pleura that is concentrated in the mediastinum, must be communicated to the œsophagus, and by the œsophagus to the stomach, both to its surface, and by the fibres of the nerves, to its intimate parts. See the Chapter on the Pharynx, the Œsophagus, &c., and also that on the Stomach.

(*s*) On these subjects again see the Chapter on the Pharynx, the Œsophagus, &c., n. 82, 83.

phagus, thus equipped and excited, may effuse the living forces of the lungs into the stomach, and from the stomach round about into its satellite viscera. Furthermore, the pleura bestows a capsule upon the aorta, the vena cava, the vena azygos, and the two intercostal nerves (*t*), and thereby inculcates and inspires into them throughout their passage, that while they respectively carry with them the soul of the heart and the soul of the brain, they are also at the same time to carry with them the spirit of the lungs, into the uttermost provinces and the innermost recesses of the kingdom (*u*).

423. III. The pleura transfers the active efforts of the muscles of the thorax, and the respiratory efforts of the lungs, not only into the peritonæum and the indigenous viscera of the cavern thereof, but also into the heart itself, its auricles, arteries, and veins, and moves them to follow the reciprocations of the lungs, at the same time that they are beating with their own pulsations. But inasmuch as the pleura, in the fulfilment

(*t*) With respect to the aorta, Winslow says, "In the most posterior part, a triangular space is left between them [the two laminæ of the mediastinum] and the vertebræ, from the top to the bottom, which is filled chiefly by the aorta" (n. 415). And with respect to the great veins and the intercostal nerves, which run down near the vertebræ, we have often observed already that the pleura covers them. "The vena azygos and its branches," says Verheyen, "and the intercostal arteries and nerves, lie in a duplicature of the pleura" (*k*).

(*u*) The reader will see the cause of this in the next paragraph.

(*x*) On these points, see the Chapter on the Peritonæum, n. 319, 320, 321, where we stated the universals of the subject, and shewed how each membrane or covering operates as a common bond upon its enclosed and indigenous viscera; and how it operates upon the coverings of other regions, which coverings in like manner serve as common bonds to their members. Thus we stated in the Chapter alluded to, that "the members are kept bound and guarded by the general bond, . . . closely and thoroughly, in proportion to their priority of place, as determined by their dignity of office, and to their usefulness in the kingdom; and this, according to the cause which they undertake in the unanimous society" (n. 321). And that "in proportion as any of the members are loose in their attachments, or more slightly held, confined and bridled by the general bond, . . . in the same proportion they are more

of its character as a common bond, flows into the members of its sphere and region, in a manner exactly accommodated to the causes and ministries in which they are respectively engaged in the general society (*x*), hence it flows into the heart, which is the ultimate chief and ruler of the kingdom, in a dissimilar manner to that in which it flows into the lungs, which are at once the servants of this king, and the satellites of the brain (*y*). For the heart governs the very helm of the body, while the lungs govern only its sails and sailyards. Hence the pleura unfolds its tissues and cords into the heart, otherwise than into the lungs: in the first instance, indeed, it goes round them both, but it immediately approaches and enters the lungs, as its proper organ (*z*). On the other hand, at the place where it passes inwards, as well as in front, it opens and separates its mediastinum into a broad cavity, and spreads its sail in such a manner, as to surround and invest only the proper tunic of the heart, or the pericardium (*a*). Thus circumspectly and with

apt and frequent to rush into preternatural modes and motions" (n. 322). This is particularly evident in the heart, which is bound down by the common bond least of all the organs, so that at the first signal, and the first impulse of the blood, it can rush into its alternate motions, and begin [its] circles. This could not be the case if the heart were tied and bound down by the pleura, instead of being connected, as it is, to the loose envelope of the pericardium. No part of the body demands a freer sphere of activity than the heart, inasmuch as it begins the spheres of activity of a number of viscera.

(*y*) The lungs may properly be denominated the satellites of the brain, inasmuch as their respirations are coincident, with respect to turn and time, with the reciprocal animations of the brains; also inasmuch as they are general auxiliaries, or provisional Animatorics, for carrying forward the nervous juice, otherwise termed the animal and vital [spirit], to its destinations; as we shall see presently.

(*z*) See above, n. 421.

(*a*) Respecting the manner in which the two pleuræ expand around the pericardium by means of the mediastinum, and afford the pericardium as well as the heart an extensive sphere for activity, see above, n. 420 (*f*); where it was shewn, that the pleura does not constitute the pericardium proper, but only goes over it as a common integument or sheath; and interweaves its fibres with the proper fibres of the peri-

wonderful art, it enables the lungs and the heart, although disparate in means of life and rate of movement, still to conspire unanimously to the same end; namely, to guard, prolong, and perpetuate the established order of the kingdom. For the pleura, convoluted around the lungs, penetrates by scaffoldings and networks all the way to their vesicles or innermost centres. The pericardium, in its turn, advances to the same centres, but around the bronchia, the vessels, and the nerves (*b*). In these, the primary goals of the lungs, and the intimate goals of the heart, as in a kind of courts or comitia, those two chiefs adjust and settle all their differences, and suddenly make a covenant by means of the blood. The terms of this covenant are, 1. That the lungs, during each alternate draught, do admit, and lend their assistance to infuse, the living spirit of the cerebrum and cerebellum into every nerve and muscle of the heart, its auricles, arteries and veins; so that the heart may perpetually enjoy the power of performing its systole and diastole, of which if deprived, it, and its vascular apparatus, would fall and die (*c*).

cardium, by something analogous to cellular tissue. By this means the mediastinum is prevented from insinuating itself in any other than the most général manner, into that innermost sphere designed by the pericardium for the heart's activity: and this, because the activities of the heart are altogether different from those of the lungs. Hence it follows, that the pleura is the common bond and covering of the lungs, but not of the heart, the pericardium being the common bond and covering of the latter. The descriptions given by our Authors will enable the reader to form an idea of the mode of communication between the pleura and the pericardium. "The external lamina [of the pericardium]," says Winslow, "... is formed by the duplicature of the mediastinum. It is connected to the proper bag of the pericardium by the cellular tissue of that duplicature; but leaves it where the pericardium adheres to the diaphragm" (n. 417). And Lancisi says, "The external coat of the pericardium is continuous with the outermost coat of the lungs and of the mediastinum" (n. 419).

(*b*) See above, n. 420, 421.

(*c*) It will be seen in the Part on the Heart, that the heart is raised into diastole entirely by the afflux and impulse of the venous blood, and that its nervous fibres being thus stretched or extended, react proportionably, until they incite and force its muscle to perform systole:

2. On the other hand, that the heart do pour forth through the venous artery, all its own or the body's blood, for the lungs to conduct to those innermost places of comitia or meeting, for the purpose of renewing the terms of the covenant every time; so that the lungs likewise may perpetually enjoy the power of maintaining their respiratory alternations, of which if deprived, they and their air-pipes would collapse and perish (*d*). 3. That

also that the nervous fibres that flow into the moving fibres of the heart and its auricles, contribute in no degree to its reciprocal motions, further than that they give the faculty whereby the heart is enabled to perform those motions, according as the influx of the blood takes place: and that this belongs entirely to the heart's organism. But as a necessary condition of the fibres communicating this faculty and power to the heart, they must be always turgid with spirit; for the power of action possessed by the muscles is attributable to the spirit of the nervous fibres. In the Part alluded to, we also purpose shewing, that the lungs, as performing a work vicarious of the animations of the brain, infuse this spirit into the cardiac nerves, and hence infuse the power of action, in a secondary sense, into the heart; and that the heart dispenses its acquired power, according to the causes demanding it in the body: consequently that the heart, without this assistance from the lungs, would sink with weakness, and presently die. Hence it follows, that the lungs do not influence the systaltic motions and measures of the heart more particularly, than by simply communicating this power. Such would appear to be the secret that lies hid in the amazingly intricate connexion between the heart and the lungs. We may infer from this example, what it is that potency alone can do in any subject, and what general effects can result from it; since the subject itself has the liberty of performing its motions, or beginning its own conditions, either from causes proper to itself, or from foreign impulsive causes. We observe something analogous to this in the rational mind. The soul does no more than infuse into it the power of perceiving, thinking, judging and willing; but in other respects, does not in the smallest degree trench upon its liberty of operating according to causes exciting it, either extrinsic, inferior, or intrinsic; and of instituting any conditions and exercitations that it pleases. The images of this law are very vividly presented by the heart and lungs.

(*d*) We shewed in the Chapter on the Lungs, that the heart extends its sphere of activity no farther than the first threshold of the lungs; and that in throwing forth its blood into the lungs, it throws it beyond

the heart and the lungs do live in separate chambers, and in divided courts of office, disparate in their respective rhythms and harmonies, and as it were in concordant discord (*e*). 4. That the mediastinum of the pleura be security for their friendship, and that with this view, it secure and seal up the middle boundary, and there intromit the spirit of the brain into the

itself, through a capsule continued from the pericardium; likewise that the active force of the lungs meets it at the above threshold,—the force that flows forth from their very centres, from which it governs their circumferences. Hence it is plain that there is a kind of compact between the heart and the lungs, whereby the former is bound to send forth all its blood through the venous artery, and the lungs to conduct it to their intimate chambers, where the above-mentioned power resides; and another term of the compact is, that by this blood, the lungs are to be gifted with the power of respiring; for in this case the vesicles can be opened by the incumbency and pressure of the air. But if this blood, when driven from the heart, did not flow all the way to the intimate reticular plexuses, then the contractility or renitency of the lungs against the pressure of the atmosphere would have been so great, that not the smallest thread or pipe of the bronchia could possibly have been opened. Thus the cardiac blood gives the lungs the ability alternately to admit and expel the air, in short, to respire: so that there are certain powers which the heart and the lungs divide between them. But external causes actuate them both to perform their reciprocations; the advancing venous blood actuates the heart; the incumbent atmosphere, the lungs.

(*e*) One member never apportions and imparts to another anything more than potency; and hence it never deprives that other of the liberty of acting thus or thus, in one way or in another. As a parallel case, when any individual man is possessed of knowledge and wisdom, or if you prefer the illustration, when he is possessed of wealth, he is not on that account bound by such possessions any further, than to dispense and use them, according to the calls made upon him, either natural or accidental. This is the reason why the lungs in no degree trench upon the heart, nor the heart upon the lungs; but both of them extend their operations and vary their exercises in divers ways, within the limits of their given sphere and acquired power. Hence respectively to the powers given to them mutually, the utmost concord prevails between them: in this sense we use the terms, discordant concord, and concordant discord.

heart through the nerves, and the blood of the body into the lungs through the vessels; and that in this place, the mediastinum and pericardium, besides keeping guard, do themselves enter into a similar subordinate covenant (*f*). This covenant was agreed upon in the intermediate moment between the uterine and post-natal lives, that is to say, at the first moment of birth (*g*). Thus the brains, by means of the lungs, communicate to the heart the opportunity and power of acting: but it is the

(*f*) This will be evident if we duly examine and consider the connexion subsisting between the mediastinum and the pericardium, and the influx of the two into the lungs, and *vice versa*. For where the mediastinum joins the pericardium, it also surrounds the great pulmonary vessels, investing them with a kind of capsule; so that the cardiac blood flows into the lungs within a sheath formed by the pericardium and mediastinum conjointly. "The trunks of the aorta and pulmonary artery," says Winslow, "have one common coat, [namely, the pericardium and mediastinum,] which contains them both as in a sheath, and is lined on the inside by a cellular tissue that is chiefly accumulated in the spaces where the trunks, and the sides of the sheath, come into mutual apposition and contiguity" (n. 417). The other authors we have cited agree in this view: see Lancisi, n. 419. In this way, the pleura and pericardium are pledges and sureties, for they cover and seal the entrances and exits; and there unite in a compact, to transmit the blood of the one through the vessels, and the spirit of the other through the nerves. Of the passage of the nerves through the pericardium we shall speak presently.

(*g*) I shall endeavor to shew in the Epilogue, that there were different terms subsisting between the heart and lungs during uterine life, from those which are in force during the life after birth; and that in the former case the heart must have acquired its power of action immediately from the fibres of the cerebellum, without receiving any assistance from the lungs: consequently that the heart could not then have been raised excepting by causes inspired by the brain; and that at this time it lay close to the lungs: but that during the interval of birth, when the future man was neither an embryo nor an infant,—when he first greeted the atmospheric world, and entered upon his second stage of life, and took the first draught of the air,—that then, I say, the heart repelled the lungs, and removed them out of contact with it; and this, by the pouring of the blood into the pulmonary artery, and consequently by the extension of that tube, or limit; and likewise, after

blood that excites the heart's motions and alternate vibrations; the order being actually the reverse of what it was in the prior life, when the heart lived in the womb (*h*). This is the reason why the heart and its veins and arteries, as well as the nerves of both the brains, are kept constantly in the stream of the respiratory motion of the lungs, by means of the pleura, the mediastinum, the pericardium, the diaphragm, and the peritonæum; and why the vessels, while they carry with them the soul of the heart, and the nerves the soul of the brain, are also bound to carry with them the spirit of the lungs, into the uttermost provinces and the innermost recesses of the kingdom (*i*).

the lungs had been filled, by the indrawing of that part [of them] which surrounds, and formerly pressed upon, the præcordia.

(*h*) See note (*g*) immediately above. It is nothing more than a consequence in the unbroken chain of causes, that in uterine life, the heart was excited to its vibrations by internal causes alone, that is, by the spirit of the fibres of the cerebellum; and at that time acted upon the blood, by means of its muscle, in correspondence to the excitation of the fibres: and the same remark applies to its arteries and veins. But that in the atmospheric, mundane, or post-natal life, the heart, actuated solely by external causes, namely, by the influent venous blood, acts according to its peculiar structure; thus in a way directly the reverse of the former. In short, that in its golden age, in the womb, it lived solely under the auspices of nature, whereas afterwards it lives under the auspices of the body. For this end the lungs are opened, and form their covenant, as we said above. These fortunes of the heart extend also to its whole kingdom, and to all the parts that minister therein; for all are subject to the word of the heart as their chief and ruler, as well as to the word of the lungs.

(*i*) It has been shewn already at considerable length, that the lungs flow not only into the peritonæum and its viscera, but also into the arteries, and into the nerves of both nature and the will,—consequently into both the natural and voluntary actions. I will now state the true reason of this influx. This reason is, that at the moment when the lungs are acting, the brains, by their animations, may tranfuse their spirit through the nerves into the whole of the corporeal system, for the lungs, by their vicarious operation, to move onwards to its ultimate goals; and by virtue thereof, may infuse the power of action into all things. For as the lungs act upon the heart, so they act upon all the arteries and veins of the heart, since the heart endows these with a property or

With this end in view, the cardiac nerves pass through the pericardium (*k*), and the latter, continuous with the mediasti-

faculty analogous to its own. This in no way destroys the variety of conditions, as we said before, but rather gives the power of varying them, according to any invading and inciting causes. This is the true reason why the pleura and peritonæum invest the arteries and veins, great and small, with a particular capsule or duplicature; to wit, that they may enter the minute organic parts of all the viscera with the same spirit or power, and institute there the same play, as the heart and the lungs institute between themselves.

(*k*) The passage of the cardiac nerves through the pericardium, is a matter that belongs properly to the next Part of our Work, in which we intend to treat of the Heart; but to preserve the continuity of the subject in the meantime, I will here make a short excerpt from Lancisi's description. [After stating that the nerves supplying the præcordia may be reduced to five classes, he proceeds to say, that] the first class of these nerves, namely, the par vagum, "gives off a branch which penetrates the pericardium in company with the vena cava, and goes to the right auricle; also another branch, which runs back under the pulmonary artery, and supplies several large branches to a considerable plexus situated posteriorly between the pulmonary artery and the aorta, at the base of the heart, that is to say, at the place where the ductus arteriosus passes between these two arteries." And further, that "the nerve of the fourth class, or intercostalis inferior, arises by several origins below the axillary nerves, between the third and fourth dorsal vertebræ, and then passing obliquely, is corroborated by the third ganglion, from which several branches, penetrating the pericardium, and running along the superior vena cava and the right auricle, are dispersed to the heart, to produce ultimately the before-mentioned plexus," &c. (*De Motu Cordis*, &c., lib. i., sec. iii., cap. iii., prop. 48.) This shews that the mediastinum and pericardium are sufficiently trusty guards and securities against any nerve, however small, passing into the sphere of the heart, without having been excited by the lungs to transfuse the spirit into the nerves of the cardiac plexus. Thus much, I think, cannot be denied, that the nerves, when roused by action in the body, pour forth the spirit in increased quantity; a thousand experimental facts shew such to be the case: see below, n. 424 (*q*) and (*r*). And it is equally indubitable, that the pericardium vibrates in unison with the respiratory movements of the lungs, for it is continuous with the mediastinum, embraced and encompassed by both the lungs, and connected inferiorly with the diaphragm.

num, loosely invests the heart and its auricles, and the heads of the great arteries and veins (*l*). For the same reason, the heart lies between the two lungs, but lies freely, and with its flat portion resting upon the middle of the diaphragm (*m*). In a word, this is the end of all the labyrinthine windings of the pleura and of the peritonæum; to wit, that the heart may lie shut up, like Jason's golden fleece, in the middle of this labyrinth, and may see round it on all sides the arteries and veins,—wandering over the whole field of its kingdom, and animated by the breath of the lungs,—performing their offices aright under the perpetual auspices of the cerebrum. But the heart looks upon the blood that it sends forth into the lungs, as it were from behind, and not as its own, but as belonging to the lungs (*n*), and as being on its passage to the ultimate stations of the cerebrum itself in the body; and when it has been lustrated there, as in a higher region, the heart anxiously awaits its return to the inferior provinces, that is, to the provinces of the body; in order that it may then have it at its own disposal (*o*).

(*l*) The pericardium covers the auricles and vessels of the heart, in the same manner, that is to say, as loosely, as it covers the heart itself; and this, in order that the pulmonic motion may at the same time be carried into the vessels of the heart. "Its base," says Winslow, "has a particular elongation, like a little head, which surrounds the great vessels as amply as the other portion surrounds the heart" (n. 417).

(*m*) On these subjects Winslow remarks, that "at the lower edge of the left lung, there is an indented notch or sinus, opposite to the apex of the heart, which is, therefore, never covered by that lung, even in the strongest inspirations" (n. 387). And again, that "the pericardium is closely connected to the diaphragm, not at the apex, but exactly at the place which answers to the flat or lower side of the heart," but that "the rest of the bag lies upon the diaphragm without any adhesion" (n. 417).

(*n*) The reader will find these points explained above, in the Chapter on the Lungs, n. 408.

(*o*) I say that the blood mounts to the supreme region, when it passes from the heart into the lungs. It was observed before, in the Chapter on the Lungs, that when the blood goes forth to the lungs, it escapes beyond the heart's sphere of activity, throwing itself into a capsule formed by the pericardium, which reaches all the way to the intimate

424. IV. The pleura not only conveys from the muscles of the thorax, the minutiæ of their actions, through the intervening membranes, to the circumference of the lungs, and afterwards, by cellular steps and arches, to the intimate channels of the blood and the air, but [it also conveys the actions] of the spinal marrow [to their destinations]; for it receives, embraces and clothes the nervous fascicles thereof, running forth into the circus and amphitheatre of the thorax,—I mean, the dorsal and intercostal nerves,—almost immediately [on their exit from the vertebral canal], and leads them by the hand to the moving muscles (*p*); and so holds the reins, that the medullary spine inflows in constant order with its own animated forces, as well as with those of the cerebrum and cerebellum, into the moving fibres of the chest, from which proceed the respiratory actions. Thus

parts of the lungs; and delivering itself up to the rule of the lungs, and submitting to be purified of its serous scoriæ in those intimate parts. It passes into a higher sphere when it passes into the animatory sphere of the brains, which prevails in the lungs. In fact, the only universal motions in the body are those of the brains and those of the heart. The animatory motions of the former depend upon the animal spirit; the motions of the latter depend upon the blood. Immediately after birth, the respirations of the lungs unite, so far as time is concerned, with the animations of the brains: and hence the blood carried up to the innermost parts of the lungs, is taken into the sphere of activity of the brains; in fine, into a higher sphere; and is never submitted to the jurisdiction of the heart, until it has returned from thence.

(*p*) We before pointed out, that the pleura fastens upon the dorsal nerves that follow the curvature of the ribs, and encloses them in a capsule, immediately after their exit from the vertebræ; and it appears furthermore, from all the neurological authorities, that it also fastens upon the great intercostal nerves, just at the point where the branches producing them issue from the intervertebral spaces, and combine to form those two nervous trunks. The pleura straightway binds them down; and particularly their costal or dorsal branches, which it tightly reins and curbs. And there are certain ganglionic nodules, into which the nerves plunge as they issue through the foramina, and in which they knot themselves, before they pass into the great intercostal nerves. The pleura covers these likewise. Thus it disposes the nerves themselves, from their very cradles to their ultimate stations.

the pleura, by a wonderful piece of coöperation, guides and governs these nerves in their descent, all the way from the distances nearest to the starting-place, to the uttermost goals of the course; in other words, it governs the pneumonic play, from the first causes of the principle, through the intermediate causes, to the ultimate causes, or the ends; and precludes all mischance and wandering from the case (*q*). Hence it takes care that the systaltic motions of the spinal marrow,—its alternate animatory movements,—fall into unanimity and unity with the alternate respiratory movements of the lungs (*r*). The pleura not only stamps the actions of the spinal marrow upon

(*q*) Not only does the pleura determine the outward passage of these nerves along the ribs, and their insertion into the muscles, but it also excites them to operation, by its alternate contractions; for even the smallest active force, whether consisting in traction, pricking, or straining, or in warm contact, or breath from the mouth, (according to the experience of many writers,) rouses the fibres of the nerves to operate correspondently upon the muscles into which they flow. This has been tried and proved to be the case after death with respect to several muscles, particularly those of the heart, the stomach, and the diaphragm; but of the experiments alluded to, we shall speak more at large in another place. Hence it cannot for a moment be questioned, that the pleura, by immediate contact, by means of its circumscription of the nerves, and of its close application to them, reacts upon them, and thereby upon the muscles, to the same extent that the muscles act upon it; and the more certainly and constantly, since it adheres to the muscles themselves, or at least to their coats. So again it is unquestionable, that the pleura introduces the branches of the nerves, into the muscles: according to Winslow, "The cellular portion of the pleura . . . even penetrates the muscles, and communicates with the cellular substance in their interstices, all the way to the external adipose membrane on the convex side of the thorax" (n. 415).

(*r*) Were we to bring forward all the details to be met with in the pleura, or, we should rather say, in the thorax, that concur to prove the coincidence between the motions of the spinal marrow, or what amounts to the same thing, of the cerebrum and cerebellum, [and the motions of the lungs,] they would of themselves occupy a large space. It is not necessary to particularize more than a few of them in this place; but there is scarcely a single point in the mailed and tunicated parietes of the thorax, that does not go to prove the doctrine of such

the lungs, but it also returns the compliment, and conveys back the favor to the master of the games [agōnothetæ]; for it retorts and carries in the corresponding alternate movements of the lungs and thorax, to the tunica vaginalis* of the vertebral theca, and to the external covering of the spinal marrow, and so to the dura mater of the latter as well as of the brain; and thus it leads round the influx and reflux of causes and effects in an everlasting spiral (*s*). For the pleura is implicated, by contiguous tissues and intersepta, with the vertebræ, and their tunicæ vaginales. The twelve pairs of ribs, to which it serves as a periosteum, are also planted upon the vertebræ, in the

coincidence; all things so without exception attest this union of motions.

(*s*) It is a general law in all the spheres of activity in the body, that the reaction of their parts corresponds exactly to the action, this being the source of their natural equilibrium: so that in these respects they possess properties analogous to elasticity: thus we observed before (*q*), that the pleura reacts upon the nerves of its muscles, to the same degree that the muscles act upon the pleura. The like condition subsists between the spinal marrow and the pleura. For in proportion as the spinal marrow acts by the nerves upon the muscles of inspiration, in the same proportion the muscles react upon the spinal marrow; and both the action and reaction are communicated through the pleura. This gives rise to a certitude, habitual character, and constancy, and to a certain perpetuity, in all actions. But with respect to the cerebrum, cerebellum, and medulla oblongata, there is indeed a similar action and reaction between them and the muscles, by means of the pleura; but with this difference from the former case, that the reaction is referred, as it were through a circle, to the spinal marrow; namely, through its exterior tunics, and so towards its interior parts; as will be pointed out presently. Furthermore, this reaction passes directly to the very fibres and sources of the spinal marrow; for any friction, handling, or contact of the nerves, just like any sensation arising from touch, creeps up along the fibres to their principles, and incites them: this is the case with the chafing of the nerves by the pleura: hence this reaction is determined to the spinal marrow by two ways; and thus we have incessant action as a consequence of incessant reaction.

* See Vieussens, *Neurographia Universalis*, lib. ii., cap. i., De Membranis Spinalis Medullæ, where this tunic is described.—(*Tr.*)

manner of arched levers upon their bases or fulcra. And as this osseous grate of the chest rises and falls alternately, the several ribs so vibrate their vertebræ,—the vertebræ so drag, stretch, chafe, and irritate the tunica vaginalis of the theca, and this, the common proper integument of the spinal marrow, and this, the continuous dura mater of the brain (*t*), that all these parts go off into the same rhythmic numbers and measures as the chest; and thus the alternate respiratory movements of the lungs inevitably fall into unanimity and unity with the alternate [animatory] movements of the spinal marrow, the cerebellum, and the cerebrum.

425. V. The pleura, in its character of charioteer and director, sitting on the seat of its chariot, governs and controls not only the nervous reins, or the spirit of the fibres, but also the arterial reins, or the blood; the spirit, that is, and the blood, as they are flowing into the moving fibres of their muscles; for whatever governs the one must also govern the other (*u*). It so administers the vessels and dispenses the arterial blood, that it takes out no greater supplies of the latter from the trunk of the passing aorta, sends away no more to the muscles, and sends back no more into its veins, than the end in

(*t*) These particulars cannot yet be corroborated by their proper experimental proofs; that is to say, we cannot yet shew how the vertebræ, alternately slanted by the raising up of the ribs, operate upon the tunica vaginalis of the vertebral theca, and how this operates by its muscular power, and a number of other means, upon the common external covering of the spinal marrow, which is a continuation of the dura mater. But that these experimental proofs favor my views, will be seen in the Part on the Medulla Spinalis. In the meantime, all who are sufficiently acquainted with anatomy may see and comprehend the truth, from a knowledge of the connexion of the parts.

(*u*) Anatomy furnishes innumerable illustrations of the fact, that the motions of the muscles depend upon both the blood-vessels and the nerves; that is to say, upon the blood that runs through the vessels, and upon the spirit that runs through the nerves. For when an artery or nerve is either cut, or pulled or dragged asunder, or wounded, or blocked up, the motion of the muscle supplied by such vessel or nerve suddenly suffers, is dulled, falls off, and ceases. Thus what regulates the one must also regulate the other.

view, that is to say, the existing state of the respiration taken in conjunction with the [bodily] actions, demands and in a manner calls forth. To ensure this result, the pleura brings off its intercostal arteries, not obliquely but at right angles, from the great and common artery (*x*), and afterwards binds them

(*x*) We have often observed before, that the blood is not intruded into either the viscera or the muscles by the power of the aorta; but is invited from the bed of the aorta, according to the wants of each particular viscus. The reason thereof is, that this great artery, merely propelling the stream of blood onwards along its branches by the action of its muscular coat, cannot possibly supply the different viscera with their proper quantities and peculiar qualities of blood; for each member demands more or less according to the intensity of its action, and one quality or another according to the nature and mode of its operation, or according to the character of its function. The same may be said of the muscles: those which are called into more vehement and frequent motions, at the command of either nature or the will, require a greater or lesser quantity of blood; which cannot be regulated in any degree by the aorta. Thus the intercostal or respiratory muscles, when conspiring powerfully with the voluntary actions, demand different quantities of blood, according to the degree, and the particulars, of the coöperation. This will become still more evident in the Part on the Motive Fibre. Thus the intercostal arteries, which supply the respiratory muscles, come off perpendicularly from the trunk of the aorta, in order that the latter may arrogate to itself no authority over them: for the more perpendicularly, the less can the aorta intrude any portion of the sanguineous stream. The very direction and obliquity cause the torrent of blood to be determined hither or thither. All the blood that runs out from the aorta at right angles, escapes beyond its point of determination; according to the plain shewing of mechanics and geometry. Moreover, it is of great importance to the whole kingdom, that the vessels destined to be subservient to respiration should be entirely dependent upon the will of their muscles, and in no degree upon the aorta. "The inferior intercostal arteries," says Winslow, "are commonly seven or eight in number on each side, but sometimes they amount to as many as ten: this happens when the superior intercostals also arise from the descending aorta, in which case, the latter run obliquely upwards. . . . They arise in pairs from the posterior part of the descending aorta, as far as the diaphragm, and run out transversely towards each side, on the bodies of the vertebræ."

straitly with its membranes and thongs, and conveys them along the curvatures of its wheel, the ribs, each to its particular goal, and presently gives them up to the muscles demanding them. And the better to secure an abundance of the valuable gifts that it is to distribute, and to prevent itself from ever being reduced to want, it also extracts auxiliary forces from the mediastinal arteries, consequently from the mammary, diaphragmatic, and œsophageal arteries; in fine, from all the springs and streams of its own region (*y*). This blood, which

(Exp. Anat., Tr. des Arteres, n. 115, 116.) And Boerhaave says, "The branches of the arteries are observed to have various modes of origin; they generally arise from their trunks at acute angles, less frequently at right angles, which, however, is the case with the intercostals." *(Inst. Med.,* n. 132.)

(*y*) As there are infinite varieties of muscular motions, so there are infinite varieties of requisition of blood. For the muscles, whether abdominal, or pectoral, or lumbar, or brachial, or to whatever region belonging, by the exceeding vehemence of their reciprocations, occasionally demand a great abundance of blood, so that sometimes the aorta can scarcely stuff or satiate their greedy maws; in which case the intercostal muscles might easily be deprived of their share, and become bloodless, and the lungs might give up the ghost. As the surest means of obviating this mortal danger, care is taken not only that the intercostals shall copulate by frequent anastomoses with the mammary and phrenic arteries, but also that the pleura shall be supplied by the proper vessels of the mediastinum that arise either from the aorta or the subclavian artery, and by its other vessels that come from the mammary, phrenic, and œsophageal arteries: for the mediastinum is the plane in which the pleuræ of both sides meet as in a common hall; consequently the pleuræ, like circumferences, can call forth all the blood they need, and hence summon it by these means from the universal body. "The arteries and veins of the pleura," says Winslow, "are chiefly ramifications of the intercostals. . . . The internal mammary and phrenic vessels likewise give some branches, which communicate very freely with those that come from the intercostals. The mediastinum has its own particular vessels, the mediastinal arteries and veins, which are commonly branches of the subclavian vessels. The internal mammary vessels supply its anterior branches, the phrenic, its inferior, and the intercostal and œsophageal, its posterior" (n, 415).

the muscles neither demand nor invite (*z*), the pleura scatters about, and carries in rills over its membranous web, and thus so completely dyes and saturates it with sanguineous purple, that it constantly maintains the ever mediate and elastic character, derived from its original principles, whereby it is enabled to serve as the just level and rule of the respiratory motions (*a*): and the residual or superabundant portion of the blood, the pleura sends away into its intercostal veins, (which it keeps under control in the same manner as the arteries,) and from them into the vena azygos. There is a particular respiratory field, differing in extent at different times, according to the number of muscles coöperating, and according to the sphere of activities into which the associate respirations enter and expatiate. The common receptacle of the blood of this field is the vena azygos or vena sine pari (*b*), in which vein the sanguineous

(*z*) See above, notes (*x*) and (*y*).

(*a*) The pleura is exceedingly rich in blood-vessels, nay, absolutely replete with them. In the words of Winslow, "It is . . . plentifully stored with blood-vessels and nerves. . . . These [vascular] ramifications are exceedingly numerous, and for the most part very small" (n. 415). And Heister says, "It [the pleura] has numberless arteries, arising from the intercostal, mammary, and phrenic arteries" (n. 411). The condition and state of every membrane, as in the present case, of the pleura, is principally dependent upon the supply of arterial blood, and its just proportion with respect to quantity. If the supply be excessive, (which it is during inflammation, ardent fevers, and the like inundations of blood,) the membranes become rigid, and act more than they react. On the other hand, when the supply is defective, the membranes become flaccid, fall into gathers, and are simply passive. In either event they lose their elasticity.

(*b*) We treated of the spiratory field, of the blood of which, the vena azygos is the receptacle, in our *Economy of the Animal Kingdom*, treatise i., n. 566, 567, 568; and treatise ii., On the Coincidence of Motion between the Brain and the Lungs, n. 25—30. But lest the reader's mind should be unable to follow the argument, from being altogether without experimental illustrations, I will transfer to this place from my former Work, a simple description of the vena azygos, compiled from Lancisi, Eustachius, Morgagni, Winslow, and Vieussens;*

* The chief part of the following description appears to be derived imme-

streams are collected from the whole boundaries of the field; while the streams that are extraneous to it are discharged as

and so enable each individual to form conclusions for himself. The vena azygos obtains its blood principally from the vertebral sinuses, the intercostal veins, the spinal nerves, and from a great number of muscles. In man it is a single vein, and placed on the right side, running near the vena cava and the right auricle of the heart; though in some subjects there is a lesser vein,—the semiazygos,—on the left side. The vena azygos is also single in the monkey, the dog, the horse, and some other animals. It lies on the left side in the hedgehog and the mouse. There are two veins corresponding to it, in the ox, the goat, and the sheep; also in the pig; but in the latter the left vein is so disposed that it receives its blood also from the lower ribs of the right side. In gallinaceous fowls there are four such veins, two on each side. The vena azygos of the human subject joins the vena cava outside the pericardium, and upon the right bronchium, round which it turns; it is also united to the trachea by strong fibres and minute vessels, which penetrate all the way to the internal surface of the latter. In the monkey, dog, and cat, it inosculates with the superior vena cava inside the pericardium, and near the right auricle of the heart. In the horse, it enters the base of the right auricle by one orifice; in the ox and pig, by two orifices, but which are only divided from each other by an intermediate muscular septum. In birds, all the veins answering to the vena azygos discharge themselves into the right and left axillary veins. The human semiazygos, when present, runs to the left subclavian vein. The vena azygos lies inside the thorax, opposite the roots of the ribs, along the right side of the vertebræ, and between the membranes of the pleura, [that is, in the posterior mediastinum.] It has valves, like other veins; and at its inosculation with the vena cava, it is furnished with a muscular semicircle or semisphincter, which is supplied by a particular branch of the spinal [intercostal] nerves. A similar muscular guard is observed in the semiazygos or left vein, when present, at the place where it joins the subclavian. At its lower end, the vena azygos sometimes communicates with the inferior vena cava, sometimes with the right emulgent vein, sometimes with one of the lumbar veins; and in its ascent it increases very greatly from receiving ten branches, into which, and particularly the uppermost, subordinate branches run from

diately from two sources, namely, from Lancisi, *Dissertatio de Venâ sine pari*, and tab., inserted in Morgagni, *Advers. Anat.* v.; and from Winslow, *Exp. Anat.*, *Tr. des Veins*, n. 39—54.—*(Tr.)*

foreign into the inferior vena cava. This is the reason why the pleura has placed its vena azygos in the centre and port of its

the trachea and bronchia. On the left side it receives six or seven branches, the uppermost of which, insinuating itself under the right bronchium, and the great artery, at the left side of the thorax, climbs over the axillary artery, and ultimately falls into the left axillary vein. The fourth in order of the left branches [beginning from the lower end] is larger than the rest, and may be regarded as a little trunk of union; it comes originally from the testes, and in females from the uterus; and increases by streamlets joining it as it ascends. The vena azygos often joins the vena cava, at other times the emulgent vein, and the mammary veins; but it derives the greater part of its blood from the intercostal muscles, both of the right and left sides, from the serrati and pectorales, from the lumbar and vertebral muscles, from the diaphragm, up the side of which it creeps, from the sinuses of the spinal marrow, from the pleura, from the adipose membrane, from the sternum, and from other sources. Thus it receives nearly all the inferior intercostal veins of the right side, (which in their turn communicate with the rest of the thoracic, and with the mammary veins); also the left intercostal veins, though seldom the whole of them; for the superior veins run often to the left subclavian vein. Inferiorly, a branch of considerable size arises from the two last intercostal veins, and from those of the abdominal muscles, and rising to the vena azygos, unites with it about the last rib: and sometimes branches come from the straight lumbar veins, and from the inferior diaphragmatic vein. But the variety exhibited by this vein while it is forming its trunk,—the variety both in course and anastomoses,—is so very great, that it is not in our power to dwell upon all the particulars thereof. We must add to the foregoing, that this vein receives no blood from the three superior ribs, but for the first time from branches between the third and fourth ribs. It is well worthy of observation, that the intercostal nerve puts forth a trunk in the neck from both its inferior ganglionic plexuses, which trunk divides on each side into branches, about the fourth or fifth dorsal vertebra; and these branches afterwards again unite into one. They send out cords or fibres on each side, which in divers ways go to, cross over, and embrace, all the branches of the vena azygos, as well as in various places the trunk of that vein; and higher up, the vena cava; and creep over the branches with erratic windings and ivy-like tendrils; and after having thoroughly mingled, by minute twigs or fibrillæ, partly with the same intercostal veins, partly with the dorsal nerves, they perforate the diaphragm, and, descending through the ab-

motions; has tied it down by the muscular ends of the diaphragm; has connected its upper part to the bronchia, to receive and learn from their mouth its proper momenta and degrees of action; has introduced into it all its intercostal veins, and garnished them and it with little nerves and nervous fibres, creeping in ivy-like intertwinement around their coats; has begirt its entrance or valve with a particular nerve; and has inserted its orifice into the superior vena cava, and thus consociated its blood with the blood coming down from the cerebrum, cerebellum, medulla oblongata, and medulla spinalis:—namely, in order that by way of the blood also, the pleura may maintain the harmony between the motions of the brains [and of the lungs] (*c*).

426. VI. The pleura not only moistens, fills, and distends its membranous web, and particularly the follicular down turned to, and implicated with, the external parietes, with the blood contained in its sheet of capillary ramifications; but it also moistens, fills, and distends the follicles of this down, or the cells of the cellular tissue, with the dew and rain expressed

domen as far as the sacrum, put forth various twigs to the viscera, as well as to other nerves, and ultimately to the crural nerves; and thus commix, by their fibrillæ, with nearly all the nerves proceeding from the dorsal spine.

(*c*) Nothing can be more evident from the above description, than that the vena azygos is the common receptacle of the whole of the blood that is contained within the boundaries of the respiratory field; and that this field at one time extends far below the thoracic region, to wit, to the kidneys, the testicles, and the uterus; and particularly within the spinal theca itself, since the vena azygos draws its blood primarily from the vertebral sinuses: at another time that it contracts its boundaries, and narrows itself. The innumerable anastomoses of the vena azygos with even the more remote veins, are so many plain attestations of this fact: as also are the intercostal nerves, which after saluting the vena azygos, and the whole tribe of its veins, with such repeated and joyous kisses, commix with nearly all the nerves proceeding from the dorsal spine; according to the observation of Lancisi. *(Dissert. de Venâ sine pari.)* Whoever will use his privileges as a rational interpreter, may infer the rest from the particulars of our description. See the *Economy of the Animal Kingdom*, loc. cit.

from the little arteries (*d*): and this, for the following reasons; 1. That in pursuance of its office, it may constantly maintain a state of elasticity, or power of reaction, suited to the minutest differences between the motions of the chest and the motions of the lungs, by the impletion of its pores, and thus by a corresponding state of tension or relaxation of its own substance (*e*). 2. That it may correct, with a kind of purificatory sifting, the blood destined to excite the muscles ministering to respiratory life, and prevent anything on the part of the blood from outraging or interrupting those eminently vital actions (*f*). 3. That it may also perform the office of a Colatory of the blood, in anticipation of the lungs, and excuss, wash away, and take off as with a rough file, the impurities of the serum of the blood, before it goes up into the veins, and enters the pulmo-

(*d*) It is evident from the luxuriant vascular ramifications supplying the pleura, that that membrane is constantly half filled with a particular humor circulating through its cellular tissue: for wherever arteries are present split into minute twigs, there secretion is going on. Respecting this humor, Winslow says, "The surface [of the pleura] which looks towards the cavities of the breast, is continually moistened by a lymphatic serosity" (n. 415).

(*e*) The capillary circumramification of the blood only renders the parietes of the cells, and the internal membrane, tense and rigid; but by no means reduces the cells themselves to the same state as the parietes: hence the necessity for a lymph that will distend the cells also, that is, the little spaces bounded by the parietes, and reduce them to a corresponding state: and this, in order that the pleura may retain an ever-middle nature between active and passive, and thus be enabled to serve properly as a common bond. That such is the effect of this lymph, is declared by Winslow. "The connexion of the pleura with the ribs," says he, "keeps it stretched: . . . it also renders it extremely sensitive to the least separation caused by coagulated lymph or accumulated blood" (n. 415).

(*f*) This is a consequence of the mere act of the secretion of serum by the exceedingly minute arteries with which the pleura abounds; for the arteries throw off a large quantity of especially the more worthless serum, and in this manner correct the mass of the blood. This cannot fail to be important and useful to the muscles of the thorax more immediately adhering [to the pleura], I mean, to the intercostal and sternal, or genuine respiratory muscles.

nary artery through the gate of the right side of the heart (*g*); by this arrangement and adaptation, the pleura serves, and provides for, the muscles and the lungs, at the same time that it serves, and provides for, itself; and thereby fulfils three ends at once. Hence the great frequency of anastomosis between its intercostal vessels, and the mammary, phrenic, and mediastinal vessels; and in fine, between them and all the vessels both above and below its expanse (*h*): and hence again, the correspondency between its secretion from the arteries, and the momenta and degrees of intensity in the actions of the internal and external domains of the thorax.

427. VII. To prevent these clouds exhaled by its arteries from hanging in thick beads upon its follicles and trabecular bands, the pleura immediately discusses and eliminates them through various paths commencing from its primitive threads; in a word, agreeably to the ordinary and national custom of the kingdom, the pleura presents a part to the veins, to be reabsorbed; and another part, with a similar view, to the lymphatics; to the former, in order that they may export their portion into the vena azygos, and into the superior and inferior venæ cavæ; to the latter, in order that they may export their portion into the receptaculum chyli, and so through the thoracic duct into the subclavian vein, and likewise into the superior vena cava, and into the common bed of the heart, from whence it may be carried off direct into the intimate recesses of the lungs (*i*). But the portion disliked and rejected by the veins

(*g*) This conclusion is deduced from the premises by the same process of inference as the foregoing.

(*h*) Respecting the frequency of the anastomoses, see above, n. 425 (*y*). By the mammary arteries the pleura is enabled to summon the blood from the region above it; by the phrenic arteries, from the region below it. Its power in this respect is multiplied by the anastomoses of the intercostal with the mediastinal vessels, which spring from the aorta or subclavian artery, and communicate with the mammary, phrenic, and œsophageal arteries. Thus any and everything proper to a particular member or region in the great society of the body, is also common when use and requirement dictate and demand it.

(*i*) Respecting the derivation of the venous blood into the vena azygos, and from the vena azygos into the superior vena cava, see

and lymphatics, the pleura expels through porous channels between the muscular fibres, all the way to the adipose membrane, and from it, to the external skin (*k*): doubtless in order that

above, note (*b*). Heister states that this derivation also takes place into the inferior vena cava. "[The pleura has] veins," says he, ". . . all of which terminate in the trunk of the vena azygos, and of the superior* vena cava" (n. 411); and the fact is still more evidently shewn in angiological tables. According to the same Author, the pleura has "lymphatics, which run to the thoracic duct." (*Ibid.*) The consequence is, that this venous blood meets the lymph of the thoracic duct in the right auricle and ventricle of the heart; and that the lungs then carry it off, agreeably to the proposition laid down in the Chapter on the Lungs.

(*k*) The cellular porosities of this membrane run continuously athwart the muscular fibres, all the way to the adipose covering, according to the following from Winslow: "The cellular portion of the pleura," says he, ". . . even penetrates the muscles, and communicates with the cellular substance in their interstices, all the way to the external adipose membrane on the convex side of the thorax" (n. 415). We may conclude from the analogous office of the omentum, (see n. 258, *seqq.*,) that the blood deposits its bodily part, or at least the exuberant and superfluous portion thereof, in the cells of this adipose tissue; and when we come to treat of the latter anatomically, it will be seen that there is a continuous passage through it, and especially through the cellular tissue of the muscles, with which that of the pleura communicates, all the way to the skin; consequently to the cuticular sudoriferous pores: shewing that the serosity from the muscular substance, as well as from the pleura and peritonæum, equally as from the skin itself, is thrown out by this porous channel; but only when its passages are open. And the same fact is proved by the phenomena of exudation

* Swedenborg would appear to have cited this passage in proof of a point the opposite to that which it goes directly to establish. Heister's words are, "Venæ [pleuræ] . . . quæ . . . in venæ azygos, ut et cavæ truncum superiorem omnes exonerantur." (*Comp. Anat.*, n. 255.) Nevertheless, Swedenborg's assertion that the pleura sends back its blood into both venæ cavæ, is corroborated by Winslow, who states that the "phrenic vessels . . . give [it] some branches," and that the same phrenic vessels supply the inferior branches to the mediastinum (n. 415, above); and according to Heister, the inferior phrenic veins run into the inferior vena cava. (*Comp. Anat.*, n. 256.) Hence the probable transmission of the venous blood of the pleura, if not directly, at least by anastomosis, into the latter vein.—(*Tr.*)

the residual pure part of the portion so expelled, may be stored away in the cells of the fat for future use, as is the case in the cells of the omentum; and that the impure part may be thrown out through pervious passages and pores by the skin, in the form of effluvial vapor or sweat. But should this path be obstructed, or contracted by external cold, then the above vapor or sweat is sent gyrating to the circumferences through a continual network, whithersoever its uninterrupted and permeable cellular tissue leads it; consequently, to the two goals of the mediastinum, where the centres of its circumferences meet together; and thus as it were from a stormy lake to a secure haven, where the ligaments, like docks,—themselves surrounded with an unending cellular tissue,—take it up, and pass with it to the external surface of the lungs, under which a similar tissue goes its rounds (*l*). Afterwards, this humor is expelled into the

and perspiration; respecting which we refer the reader to medico-anatomical and physical records.

(*l*) The continuity of the cellular tissue of the membranes, affords the clearest evidence of the continual circulation of liquids through them: for wherever this tissue prevails, wherever it is permeable from cell to cell, (as in the peritonæum, all the viscera thereof, in the lungs, &c.,) nothing can be more reasonable than the inference, that it furnishes a channel for some kind of humor; and the more especially when it is known, that the membrane in question is supplied by numberless arteries, as well as agitated by an alternate motion of constriction and expansion; for were even the least portion of humor shut fast in any one of the cells, some tumor, morbid varix, or preternatural corpuscule must inevitably grow out of it. The pleura, which is in a manner inflamed with minute arteries, and covered with an uninterrupted cellular tissue on the side next the ribs and muscles, and shaken perpetually with the respiratory motion, and thus stretched and relaxed by turns, cannot fail every time to shake off the sweats from its little arteries, and thereby to fill its little follicular passages with vapor. This being indubitable, the only question is, respecting the path taken through this cellular tissue by the humor enclosed. This question is resolved and settled by the tissue itself, when examined with a view to its continuity. Thus it is declared by anatomists to be continued round the whole of the thorax, all the way to the beginning or origin of the mediastinum, where it adheres very closely to the ribs and sternum; so that there appears to be scarcely any passage from the field of the

atmosphere by way of the lungs, which themselves act as a common evaporatory for the sweats. Thus the excrementitious

pleura into the cellular interstice of the mediastinum: were the case otherwise, possibly the cavity of the pericardium might be inundated with humor.[t] But below, close to the vertebræ, there runs a ligament, which goes all the way to the concave part of the lungs; that is to say, to the bronchia and the great pulmonary vessels. This ligament, from this part of the mediastinum, is continuous on both sides with the pleura, and begirt with cellular tissue, like the similar ligaments proceeding from the diaphragm and peritonæum into the liver, the spleen, and other viscera. Now if we follow this path, and accurately trace the continuity of the tissue, we shall be inevitably conducted by the pleura, through the ligament just mentioned, to the [outermost] surface of the lungs, which is begirt with a similar tissue. For nature appears to exhibit the same play here as in the other members already noticed, and indeed as in all the members. Moreover, the mediastinum embraces and invests the last portion of the trachea and the first portion of the bronchia, as well as the great arteries, and particularly the pulmonary artery, with a similar lanuginous or downy tissue; wherefore, if we follow the stream here also, a similar path will be found to conduct us again towards the surface of the lungs, from which there is an uninterrupted permeability, through similar cells, to the intimate substances of the lungs, as we shewed before; but as it appears, by the mediastinum and the pericardium. See the next Chapter, on the Thymus Gland. The cellular tissue itself, as well as the skin and the lungs, as being the evaporatories of the sweats, appear to furnish a declaration, that the humor of the pleura is either thrown outwards towards the skin in the form of sweat, or when the ways leading thither are closed, is carried inwards, that is, towards the lungs. But let us hear Winslow on the subject of this tissue, and its continuity. "The two laminæ," says he, "of which it [the mediastinum] is made up, are closely united together at the sternum and vertebræ. . . . The cellular portion of the pleura connects the membranous portion to the sternum, ribs, and muscles; to the diaphragm, pericardium, thymus gland, and vessels; and in fine to whatever lies near the convex side of the membranous portion (n. 415). The trunks of the aorta and pulmonary artery have one common coat which contains them both as in a sheath, and is lined on the inside by a cellular tissue that is chiefly accumulated in the spaces where the trunks, and the sides of the sheath, come into mutual apposition and contiguity." &c. (n. 417). These two spots,— namely, 1, where the dorsal ligament is continued from the pleura to

vapor of the pleura that is not imbibed by the veins and lymphatics, is condemned to banishment, and cast out through either the cuticular or the pulmonary sudatory; and in truth by one or the other way, or by both at once, according to the state induced upon the blood, the tunics, the muscles, the lungs, the channels, and the pores, by the temperature of the air, the motion of the body, the storms of the animal mind, the heat of the will, the assault of disease, the decline of life, or the natural constitution. Hence the thoracic region throws and circumagitates its pleuritic humors hither and thither, uncertain of their course, through the shallows and meanders of this tunic, variously according to every fluctuation of the desires of the rational mind, of the lusts of the animal mind, and of the pleasures of the body; and the humors, therefore, not unfrequently stagnating, become compacted into glandiform tumors, which must be termed preternatural in natural life, and natural in preternatural life, such as human life generally is at this day (*m*).

the lungs; and, 2, from the mediastinum,—are in the very centre of the circumferences, consequently in the centre of the motions, and constitute the axes; and therefore, according to the law universally observed in this kingdom, the humor is determined thitherwards, and so to the surface of the lungs, the whole circuit of which may be said to be a central periphery relatively to the pleura and the mediastinum, of which indeed it is formed.

(*m*) It has been a question among anatomists, whether or not the pleura, pericardium and peritonæum are beset with glands; and whether these are the springs of their humors. We shall discuss the subject of glands in the pericardium, in the Chapter on the Thymus Gland. With respect to the pleura, it is agreed on all hands, that multitudes of glands have been found and seen in it, when in a diseased state. "Some writers," says Heister, "attribute glands to the pleura, but without good reason. . . . All observations to this effect have been made upon diseased subjects, and derived from morbid conditions; but glands have never been shewn in the pleura, so far as my knowledge extends, in healthy bodies. Hence I am induced to think, that the corpuscules taken for glands, are nothing more than tubercles, the products of disease, which have owed their origin to the stoppage of earthy or viscid matter in the delicate little arteries of these mem-

428. If we trace the cellular tissue of either pleura,—the tissue permeable by the lymphs,—we are conducted not only to the middle junction and partition of the two, that is to say, to the mediastinum, but also from one pleura to the other, and so round the chest, in an everlasting circle (*n*): for the same cel-

branes" (n. 411). This opinion may be reasonably concluded to be near the truth, from the fact that the arteries, divided into the minutest capillaries, and besetting the parietes of the cells of this tissue, can secrete their humors equally as well as if they were split into similar threads in glands; so that the presence of glands would be of no use in this instance. But as none of the coverings of the body are subject to so many irregularities and uncertain vibrations as the general coverings of the pleura and peritonæum, it is no wonder, if in the decline of life, a number of glandular excrescences spring up, furnishing the means by which nature endeavors to amend and repair her losses. In this view it seems impossible to deny that the like reparatories may exist in some even apparently healthy subjects: so that in this manner the opinions of those who deny and those who affirm the existence of these glands, are reconcilable. See below, n. 438 (*x*).

(*n*) We all know that the two pleuræ, which come together in the mediastinum, and divide the cavity of the thorax into two chambers, are perfectly distinct from each other.. Thus if we trace one of the pleuræ through the circle that it describes, we are led to the mediastinum, from which we return around the pericardium to the pleura of the same side. Nor is the coalition of the pleuræ in the mediastinum of such a character, that the one pleura passes absolutely into the other, or that the two mutually interweave and fold together; but each follows its own gyre. They are merely conjoined in the mediastinum by fine cellular tissue; but in other respects are perfectly distinct. It might naturally have been supposed, that through the cellular interstice between the two laminæ of the mediastinum, there would be a passage from each pleura to that of the opposite side: but according to anatomical experience, the two pleuræ, at the entrance to the mediastinum, appear to be so firmly agglutinated to the sternum, vertebræ and ribs, that there seems to be no room for such communication. This is a point, however, requiring additional investigation; for the existence of a cellular interstice between the two laminæ of the mediastinum, is declared by Winslow in the following words. "The thorax is divided into two cavities, entirely separated from each other by a middle septum. . . . It [the cellular tissue] . . . insinuates itself between

lular and permeable tissue prevails without a break upon the muscular plane of the diaphragm, and unites the clothing of one side to the clothing of the other; and thus affords a passage between them, and equalizes their fluids; whence the communication is maintained, if not by way of the middle septum, at any rate by way of the transverse septum (*o*). This same general interpartition affords a passage to the inferior region, and bridges the gulf from the circumference of the thorax, that is, from the pleura, to the circumference of the abdomen, that is, to the peritonæum. The diaphragm is clothed by these membranes on both its surfaces, and is permeable between the two by passages that creep from cell to cell. Hence when the permeating humor comes to the goal of the one membrane, it has also come to the starting-place of the other, and so again into a field where it can commence a new career (*p*). Thus,

the laminæ of the duplicature of which the mediastinum is formed" (n. 415).

(*o*) It being doubtful whether the two pleuræ communicate with each other through the mediastinum, let us pass on to more certain matters, and follow the thread through paths that are laid down to sight. The same cellular tissue prevails over the whole of the diaphragm, between the pleura which lines it superiorly, and its muscular or proper plane: this tissue reaches from one side to the other, and thus unites the two pleuræ. We may infer the transmeability of the humors, from the extension and continuity of the porous cellular tissue through this plane. But this will be further evidenced in the Chapter on the Diaphragm.

(*p*) Respecting the circulation of the humors around the peritonæum, see above, n. 325; and respecting their place of discharge after birth, see the Chapter on the Kidneys. The only question here is, whether any humor can be transferred from the field of the pleura into the lower field of the peritonæum. This point might possibly be ascertained by means of injections thrown into the tissue of the pleura near the diaphragm, or in the diaphragm; but as no experiment of the kind, so far as I am aware, has been yet attempted, let us in the mean time simply follow the course of the cellular tissue; and as it exists both above and below the diaphragm, and the muscular plane separates it in these respective cases, we may hence consider, as I think without fear of error, that when use and necessity require it, this plane may be easily penetrated. For in all other parts of the body, where a similar

according to the usual form of law, whatever is assigned to one thing as proper thereto, is also assigned to all, as common to all; and use, necessity, and the rule of equation, regulate the supply, and dictate the channel through which it is to come. For the community lives from the property of all, whether that community be the blood, or the humor, or the spirit of the blood; or whether it be motion, or force or power of acting, or anything else whatever: such is the constitution given to all the structures, such the spirit with which they are all inspired, by the supreme mind of the body,—by that mind which is the common life of all things that belong to the body. For this reason, these two involucra, the peritonæum and the pleura, are very similar in function, structure, and nature (*q*), and are ren-

tissue lies under a membrane, a muscular plane of some kind intervenes, and is perforated by the continuous threads of the tissue; as we know to be the case in the intestines, the stomach, the pericardium, and the pleura and peritonæum themselves; the humor of the cellular tissue of which parts, makes its way around the moving fibres. In fact, the moving fibres are always disposed in such a manner, as to give a free passage at intervals. The same thing seems to obtain in the diaphragm, where, if we may judge from what happens in other parts, the muscular fibres rather promote than impede the passage. But as no humor ever crosses without invitation, into the region of another humor, it follows, that it is carried all the way thither by a common path, and that something analogous to an attractive or invitative force takes it away: according to the law that prevails everywhere throughout the sanguineous system, where there is a kind of general conjunction by anastomosis of all the vessels, both in the thorax and in the abdomen; and nevertheless no more blood flows through any one of the anastomoses into a second branch, than is proportioned to the necessity, want and use of the member to which such branch is peculiarly distributed. The same remark applies to the rest of the humors, so that although there may be permeability, yet no more humor is detruded by the pleura and diaphragm to the peritonæum, than the law of use and necessity requires.

(*q*) In the Chapter on the Peritonæum, I was less desirous to lay down the proper uses of that membrane, than to dwell upon its advantages and benefits as a common bond. Now since the pleura is the same sort of bond to the chest, that the peritonæum is to the abdomen, therefore the generals that were stated in the Chapter on the Perito-

dered continuous with each other by the intermediate septum; and for the same reason that septum has the renal capsules connected to it underneath, which in embryonic life carried on the circulation of the chyloid serum through the cellular coats of the peritonæum and pleura, precisely as the heart carries on the circulation of the blood; and during every round of the circle, sent back the nutritious humors of both these membranes into the gyre of the blood (*r*).

næum, may not improperly be transferred to the pleura; and on the other hand, the particulars that are here accumulated respecting the pleura, may with equal justice be transferred to the peritonæum. For the one does in the abdomen exactly what the other does in the thorax: and the construction, intimate constitution, operation and nature of both, are also similar. The cellular tissue of the peritonæum, like that of the pleura, and in the same manner as it, penetrates the muscles, communicates with the cellular tissue in their interstices, is moistened with a perpetual serosity, and pierced by foramina: see Winslow, n. 415.

(*r*) I endeavored to shew in Part I., Chapter XIII., in treating of the Succenturiate Kidneys or renal capsules, that before the other members of the abdomen were initiated into their offices, those capsules administered a kind of sovereignty (n. 274); and that they maintained the circulation of the [serous] chyle, through the cellular tissue of the peritonæum, and copulated this highly nutrient and spirituous fluid, to the blood, and remitted the product into the sanguineous circulation (n. 275). But unsupported as I then would have been by facts, I did not venture to assert, that these capsules also absorbed the corresponding serum circulating through the pleura, and sent it forth in a circle through the peritonæum. But since it is now evident, that the lymph also of the pleura, during this primitive and innocent age, might have passed through the cellular tissue of the diaphragm, from the one membrane to the other, athwart the intermediate muscular fibres, (as will be further proved in the Chapter on the Diaphragm,) and thus present itself before the threshold of these capsules,—hence we may extend their office a little more widely than heretofore, claiming for them an additional power over all the humors that are transfluent through the porous tissue of both the common involucra. This is the reason why the suprarenal glands are so closely connected to the diaphragm, that they appear to be in a manner sewed into the tissue on its lower side: for according to Eustachius, "This gland is so con-

429. While we were embryos, and scarcely even mannikins, wrapped round with a multiple series of swathings, namely, the amnion, the chorion, and the womb, and the door of our dwelling was closed and guarded,—it was a matter of anxious solicitude to prevent the muscular chest from raising the ribs, or opening a space in which the tender and imperfect lungs could begin to expand (*s*); and thereby snatch the cardiac blood, and break through the bonds of the prison-house, before the appointed hour. The lungs, I say, at this time, lying in gathers and wrinkles, with their powers folded up, reclined close to their chieftain and ruler, the heart, and pressing him to their embrace, saluted him with one long and uninterrupted kiss (*t*).

nected to the external membrane of the kidneys, which is continuous with the peritonæum of the transverse septum, that without great care be used when the kidneys are taken out, one is apt to overlook it altogether, on account of its close adhesion to the transverse septum" (n. 270).

(*s*) According to the arguments brought forward in the Chapter on the Lungs, the mere expansion of the cavity of the thorax by external forces, that is to say, by the muscles, gives the lungs the opportunity and power of respiring. There were very many means by which respiration was prevented from taking place during uterine life; that is to say, not only was there no will present, and not only were all those faculties and powers that could command the external muscles, kept under absolute restraint; but the incurvation of the chest, and a number of other circumstances, took away all chance of elevation and expansion; and for this sole reason, that nature or the soul should have the undisputed sovereignty of her kingdom. For as soon as ever the lungs open the scene of life, all things proceed in contrary order, namely, *a posteriori ad priora*; but so long as nature rules, all things proceed *a priori ad posteriora*, in fine, by the synthetic way and method: which is the way of superior beings, and therefore the way of the soul in its influx into the body, (see the Prologue, n. 10); but the synthetic way is afterwards converted into the analytic (See *ibid.*, n. 12).

(*t*) This follows from what has already been laid down in these analyses. For so long as the pulmonary artery was not expanded, it reclined close to the base of the heart; but the artery swells up by repletion with blood, and thereby both it and its branches expand in length as well as breadth; so that the lungs are removed and as it were drawn

The heart, acting under the auspices of nature, performed, not fitful, but uniform rhythmical alternations, for it transmitted all the blood of its body through the foramen ovale to the hemispheres of the cerebrum, and after being all lustrated and animated there, received it on its return, and remitted and transfused it through the ductus arteriosus into the provinces of its body or kingdom. Thus the heart maintained for its blood at this time a perennial circle, from the body into the cerebrum, and from the cerebrum into the body (u). But when these destinies of the Saturnian age were accomplished, and the heart, mettlesome with its blood, and the body, with its strength, began to exhibit motions symptomatic of revolt against the guidance of nature, and burned to submit itself to the government

away from the heart; which gives each of these organs an opportunity of performing its movements without interruption from the other. And there is some ground to suppose, that the part of the lungs that immediately surrounds the pericardium, at this time retracted so as to form a sort of cavity, and thus left the heart a freer power of action.

(u) I shewed in my *Economy of the Animal Kingdom*, in the treatise on the Heart and the Blood, n. 335—340, that a circulation such as I have described above, existed before the opening of the lungs; in short, that at that time the blood of the universal body passed into the brains, and afterwards all returned towards the heart; exactly in the same manner as after this state is changed, the blood passes from the heart into the lungs, and from the lungs back into the heart. I also gave the reasons of this in the Work alluded to, namely, that whatever is formed in the body should be formed under the auspices of the brains; and that the fibre should not be able to act against the blood, nor the blood against the fibre; consequently that the body should not be able to do anything contrary to the determination of the formative power. For on these conditions alone could the whole and the parts grow in perfect harmony. And another reason is, that the brains should by this means inaugurate and initiate their primitive corculum or little heart into all the functions; lest afterwards, when left to itself and to the blood, any discord should arise between the vessels and the fibres. Further, that the brains should derive into themselves in the first instance, and carefully purify, &c., all things passing into their kingdom from the mother's store or the furniture of the ovum; that is to say, all things that can by possibility conduce to the work of formation.

of the circumambient world, and not to its own nature but to the nature of the universe,—then it made a covenant with the lungs (*x*), by the conditions of which, the latter were to assail the authority of the cerebrum, and drive the indigenous and tutelar nature from its throne, and admit, by their mouth, the breath or atmosphere of the so-much-worshiped great world, and only leave nature the power of expelling it (*y*). This said and done, the heart now poured forth all the soul or blood of its body, which it had previously sent to the cerebrum, agreeably to the present covenant, into the lungs; shutting up two of its gates, namely, the foramen ovale and the ductus arteriosus. The curtains being now drawn up, the inverted scene appears, and by means of the lungs and the muscles of the thorax,—the pleura acting as security,—we are introduced in mask upon the theatre of this visible world (*z*).

(*x*) Respecting the manner in which this covenant is ratified between the heart and the lungs, see above, n. 423.

(*y*) It was, I think, satisfactorily demonstrated in the Chapter on the Lungs, that the will governs inspiration, but nature, expiration; the expulsion of the air being, therefore, left to nature, but the admission thereof to the good pleasure of the mind, that is, to the will. See n. 394, 400. The same thing is apparent from the rapidity with which expiration is performed, as contrasted with inspiration; the latter being much the slower process.

(*z*) In another part of the Work, it is my intention to institute a specific comparison between the primeval life in the womb, and our sensitive and motive life after birth: for it is evident from all the circumstances of the case, that before the lungs are opened, an intimate life is in progress,—a life all unknown to the senses, and consequently to the rational mind; and thus unaccompanied with memory of any of the things that are done in this preliminary stage of existence: but that still we live a life of our own, and a life of the most perfect kind. After this initial period has elapsed, we cannot help thinking that we have nothing belonging to us but what our intuitive rational mind is conscious of, and has derived from its senses; or what it can recall from a fixed seat in the memory. I shall, however, shew most clearly in another place, how greatly we are deceived in these respects by the fallacies of the senses, and consequently of the reasoning mind; I shall shew that all that our minds know, and all that they possess in a fixed state in the memory, belongs only to the body, and will die with

the body; and that our veriest life will then remain,—the life, I mean, of the soul, reduced by the moral perceptions and activities of our mind into that state in which it is to live for ever. But these are matters requiring deep investigation, and which cannot be worthily expounded in this gross and general manner, while we are walking on the low ground of science, and treating primarily of a subject like the pleura.

CHAPTER VI.

THE THYMUS GLAND.

430. HEISTER. "The thymus is a gland of considerable size in new-born infants, situated in the upper part of the thorax, close behind the sternum, and lying upon the pericardium, and the trunks of the aorta and superior vena cava. It extends from the pericardium, along the trunk of the aorta, to the origin of the carotid arteries, and in some instances I have found it ascend nearly as high as the thyroid gland. It is of an uncertain, variable, or irregular figure; and in infants, of a pale, fleshy color, but of a more dusky hue in adults. Its size is greatest in infancy, when it is about three inches long, two inches broad, and an inch and a half thick: it decreases gradually during childhood, and almost entirely disappears in adults and old persons. It is of a glandular, conglomerate structure, and is surrounded by a membrane. Its blood-vessels come at one time from either the subclavian, mammary, or mediastinal vessels; at another time, from the carotids and the jugulars. Its lymphatics run sometimes to the thoracic duct, at other times to the subclavian vein, and generally speaking, have no valves. *(Comp. Anat.*, n. 256.) J. I. Mayer cites from J. de Muralto *(Observ.* xxxii.), that the latter saw a great number of crystalline vessels in the thymus, winding to the mediastinum and pericardium; and also a firm membranous duct, running from this gland to the tonsils. *(Ibid.*, not. 40.) The nerves of the thymus arise from the par vagum or from the intercostal nerve. A milky humor is occasionally found in it in new-born infants. It has no known excretory duct, and hence its use is yet uncertain. Perhaps it secretes a lymph, which it pours through the lymphatics into the thoracic duct, for the dilution of the blood and the chyle, operating in this respect like the mesenteric glands and the pancreas. Hence its use is greater in the fœtal state than after birth; because the fœtus does not perform respiration, which

is the grand agent in attenuating the blood. F. Bellinger is of opinion, that in the womb it prepares a liquid for the nutrition of the fœtus, and sends this liquid to its mouth by particular ducts; but no one has hitherto been able to find any ducts of the kind." *(Ibid.,* n. 256.)

431. Winslow. "The thymus is an oblong glandular body, rounded superiorly, and divided inferiorly into two or three lobes, of which the left is the longest. This gland is remarkably large in the fœtus, of middling size relatively in children, and very small in old persons. In children it is of a whitish color, sometimes with a tinge of red, but it is generally dark in advanced age. The principal portion of the thymus lies between the duplicature of the superior anterior part of the mediastinum, and the great vessels of the heart; from which it extends a little above the summits of the two pleuræ, so that some part of it lies out of the cavity of the thorax. In the fœtus and in young children almost as much of it lies without the thorax as within it. . . . It has vessels of its own, termed thymic veins and arteries." *(Exp. Anat., Tr. de la Poitrine,* n. 37—39.)

432. Verheyen. "The thymus is a conglomerate gland, situated in the upper part of the thorax, anteriorly, immediately under the throat, and reaching therefrom to the pericardium. It extends along the aorta and superior* vena cava, entirely concealing the former from sight, and in great part, and often indeed entirely, the latter also, as well as the origin of the subclavian vessels and carotid arteries, so that we cannot have a full view of those vessels until the thymus gland is removed. Its arteries and veins are from the subclavians, and it receives additional twigs from the jugulars and carotids. Its nerves are supplied by the par vagum as it descends from the head beside the carotid arteries. In the calf, the thymus is overrun with lymphatics, which pass from it towards the axillary vein; but whether they arise from the thymus itself I have not been able to determine. Admitting, however, what is said of the origin of the lymph in our tract i., cap. v., it will follow that the thymus has also lymphatics of its own, originating from its own substance: and this, both in man and in animals. I have hitherto sought in vain for the proper excretory duct of the thymus, nor have I ever read or heard that it has been found by any one. In early life the thymus is very soft, lax, and succulent: in old persons it is considerably more compact, and as it were wasted, being not only less in proportion, but less absolutely, than in young subjects: and

* Verheyen has "*inferior* vena cava," and Swedenborg follows him in the above quotation, but this is evidently a misprint, as noticed by Morgagni, *Advers. Anat.* v., Anim. 13.—*(Tr.)*

hence the thymus of calves and young oxen is in request for the uses of the table, and is reckoned a great delicacy; whereas that of older beasts is not esteemed. We have no satisfactory information as to the exact time when the thymus begins to decrease, but we know that it is larger in children a few years old than immediately after birth, and that it decreases again in adults. . . . The white color natural to the thymus at an early period of life, is always lost in advanced age, being exchanged for a cineritious hue. The thymus is divided irregularly into a right and left portion; and in some instances exhibits certain lines or marks, which are the appearances of a further subdivision. See lib. ii., tab. vi., fig. 2. (*Corp. Hum. Anat.*, lib. i., tract. iii., cap. vi.) Fig. 2, c c, shews the thymus gland lying upon the pericardium, and divided into a right and left lobe, of which the former is in a manner subdivided into two others, a superior and an inferior. (*Ibid.*, lib. ii.; fig. expl. tab. vi.) The thymus is pressed upon not only by the neighboring parts as fast as they grow, but also by the lungs when distended with air. This seems to account for its being particularly small in those who take strong bodily exercise; for in such persons the respiration is carried on in an increased degree, and the lungs are distended to the fullest pitch." (*Ibid.*, lib. i., tract. iii., cap. vi., ad. fin.)

ANALYSIS.

433. Wherever there are cavities, openings, hollow recesses, or rimose interstices; wherever, in fine, there are caverns and spaces, great or small; and these containing organic members, viscera, glomes, glands, lesser spherules, pipes, and similar circles or axes of circles, as it were wheels and cylinders, rotatory or revolving, moveable with life, or alive with motion;—wherever this is the case, there must be some humor, volatile vapor, and self-diffusing unguent, that will imbue and besmear the peripheries, radii, and axes, that is to say, their joints and articulations (*a*). Were there not a constant spring and stream of

(*a*) This is the case in the universal body, and constitutes a general rule admitting of no exceptions: nay, so general is it, that there is not the minutest conglomeration of vessels, or the minutest gland, or the twig of a nerve, or the fibre, that is not circumfused with its particular moisture. A humor also of a refined character flows in the rimose interstices of the nerves, and in the medullary interstices of the cerebrum and cerebellum; as we shall shew in the analysis of those parts. How much more in the great cavities and spaces where entire viscera are energizing and working with an incessant motion of expansion and constriction: in the thorax, for instance, the lungs and heart; in the throat, the ascending and descending tubes; in the abdomen, the chylopoietic viscera, round which an unctuous humor is eructated by the omentum (n. 264). [A humor is also poured] around the cerebrum, between its two membranes, and around each particular cortical mass thereof, nay, around every gland; in the scrotum, between the dartos and the tunica vaginalis testis; in the very articulations and synarthroses of the cartilages and bones. For in order that all things may act distinctly, they must necessarily be kept separate by an interfluent and circumfluous humor. Malpighi shews this to be the fact where he

some unctuous moisture of the kind, the passages would close, the pores would become incapable of perspiring, the adjacent parietes would grow together, and the boundaries between things would be confounded; an indistinct, confused, and indeterminable mass would be the result; the forces of powers, the motions of forces, the actions of motions, and the lives of actions, would fall into chaos or nothingness: the ruin of generals would involve the ruin of singulars; in short, the fate of continuous quantities would also be the fate of discriminated quantities, and *vice versa*.

434. Within and above the thorax there are certain great caverns and hollows; two, that are bounded and environed by the pleuræ and the mediastinum, and within which the lungs have their allotted sphere, and live in perpetual activity (*b*): and a third and smaller, inside the circle of the larger cavities, that is partitioned off and enclosed by the pericardium, and within which the great heart of the body has its appointed sphere of exercitation, and pulsates with busy life. And furthermore, in the throat, around the trachea, the œsophagus, the carotid arteries, the jugular veins, and the sympathetic nerves, there are certain circumscribed and empty spaces, within which those pipes, living levers and peritrochia, perform their rhythmical alternations, expand, contract, and move and play in freedom. Unless these cavities, and these members in them, were circumfused and perpetually lubricated with an oily halitus and unctuous milk, they would in a short time become parched and

states, that he observed in a case "in which the pericardium was perfectly empty of fluid," that it was "so firmly glued to the heart, that when torn off, it brought away with it a piece of the substance of the heart" (n. 418).

(*b*) The two cavities in the thorax are so completely separated from each other by the mediastinum, that all communication between them is cut off, and one cavity is allotted to each lung. "The thorax," says Winslow, "is divided into two cavities, entirely separated from each other by a middle septum." And again, "The mediastinum cuts off all communication between the two cavities" (n. 415). Wherefore the thymus is so inserted between the two, that it can supply each with its proper quantity of lymph, on a just scale, or according to the measure of its wants.

dry, they would grate upon each other with mutual friction, and sink down overcome and prostrated in powerless languor.

435. With a view to averting such perilous consequences, a great glandular body, termed the THYMUS, is interposed in the middle of all the three cavities, being thus thrown as it were into the midst of the danger, in order that it may succor and provide for all. Thus its lobular body is placed behind the sternum, between the waves of the lungs and heart, and upon the summit of the pericardium; its crura are extended upon the superior vena cava, the arch of the aorta, the bifurcation of the subclavian vessels, and the origin of the carotid arteries (*c*); and its superior stem, emerging from the stormy regions of the thorax, is carried up beside the trachea, the axis of the throat, sometimes as high as the thyroid cartilage (*d*). This

(*c*) The relative position and situation of this glandular body will be best gathered from our Authors' descriptions; which shew that it is placed between the pleuræ, at their meeting with each other, upon the pericardium and the great vessels, so as to cover the latter, and hide them from view. Its body, properly so called, lies upon the pericardium, as may be seen in Verheyen, *Corp. Hum. Anat.*, lib. ii., tab. vi., fig. 2: thus it extends inside the cavity circumscribed by the pleura. In the words of the Author last mentioned; "fig. 2, c c, shews the thymus gland lying upon the pericardium, and divided into a right and left lobe, of which the former is in a manner subdivided into two others, a superior and an inferior. . . . It [the thymus] extends along the aorta and superior vena cava, entirely concealing the former from sight, and in great part, and often indeed entirely, the latter also, as well as the origin of the subclavian vessels and carotid arteries, so that we cannot have a full view of those vessels until the thymus gland is removed" (n. 432). And according to Heister, "It extends from the pericardium, along the trunk of the aorta, to the origin of the carotid arteries" (n. 430). Now it is perfectly obvious, from the situation and course of the pulmonary artery beside the aorta at the base of the heart, that the actions of the heart and lungs meet at this spot; and hence, agreeably to the proposition, the thymus is placed between the waves of the lungs and heart; for the gland is here brought together in a body or mass.

(*d*) Heister states that a portion of the thymus rises out of the thorax, and sometimes passes as high up as the thyroid gland. "In some instances," says he, "I have found it ascend nearly as high as the thyroid gland" (n. 430). And Winslow says, "In the fœtus and

glandular organ pours its lacteal unguent into each of the cavities (e): and that it may not labor in vain, but allot and administer the proper quantity as well as quality to each, its body, divided into lobules, and broken and jagged as beseems a channel for motions and impulses (*f*), is clothed (*g*) and begirt,

in young children almost as much of it lies without the thorax as within it" (n. 431).

(*e*) The humor secreted from the thymus in infancy, is white like milk, which plainly shews that it is a gentle, innocuous, virgin unguent, that will not chafe or irritate the parts that it touches: hence at this period the gland itself is of a light cineritious hue. "In children," says Winslow, "it is of a whitish color, sometimes with a tinge of red" (n. 431). And Heister remarks, "In infants [it is] of a pale, fleshy color, . . . [and] a milky humor is occasionally found in it" (n. 430). And Verheyen says, "In early life the thymus is very soft, lax, and succulent: . . . and hence the thymus of calves and young oxen is in request for the uses of the table, and is reckoned a great delicacy" (n. 432). Morgagni also "found the substance of the gland in the fœtus, and in one case, in a fœtus of four months, very full of a whitish and almost chylous serum." (*Advers. Anat.* v., Anim. 13.)

(*f*) Morgagni mentions the division of the thymus into lobes and lobules (*loc. cit.*), and Verheyen delineates the same. (*Corp. Hum. Anat.*, lib. ii., tab. vi., fig. 2.) By this division it becomes capable of accommodating itself to all impulses of motion: for the lungs impress upon it one motion, the heart, another, and the trachea, a third; and in order that it may be adapted to all these, it must be divided into distinct glomes, corresponding to the varieties of the motion; which also is a proof, that this gland is devoted and bound to the use and service of numerous organs; namely, that it is capable of being contracted, expanded, separated or opened out, and brought together again, simultaneously with the different actions of the lungs. But were it an unbroken mass, it could not possibly be distributed in this way for the use of numerous parts, but every action would pervade it in its whole extent, and unfit it for complying with any number of organs. Its situation and connexions are sufficient to shew the particular impetus which the lungs, the heart, and the trachea, respectively, exert upon it; and how it is sometimes variously affected in different parts by modes or conditions corresponding to different organs.

(*g*) "It is of a glandular, conglomerate structure," says Heister, "and is surrounded by a membrane" (n. 430).

wherever it goes, with a cellular and porous tissue, so constructed and connected, that the unctuous drippings flow down into it; and through it as through a spacious duct, a single but continuous emissary, they flow inwards, to the centre; and then gradually and constantly to the periphery of the lungs and pleura; also by secret, but nevertheless continuous passages, around the pericardium (*h*), and athwart its moving fibres

(*h*) The investigations and explorations of anatomists, although conducted with great care, have not hitherto shewn any duct proceeding from the thymus. The observation of J. de Muralto, mentioned by Heister, is also questioned; I mean, where he says that he "saw a great number of crystalline vessels in the thymus, winding to the mediastinum and pericardium" (n. 430). There is the same absence of ducts in many of the other conglomerate glands, as in the œsophageal, arytænoid, thyroid and bronchial glands; yet as they wear upon their face a glandular appearance and character, and often contain a visible juice, it is not to be doubted that they are secerning organs, and send forth their secretions by determinate channels to the fields of their predestined uses; just like the thymus, in which, according to both Heister and Morgagnie, a milky humor has been seen. To discover then the emissary or excretory passages, we ought carefully to examine the proper coat of this gland, and to investigate its communication with the surrounding cellular tissue; for it seems to be certain, that it sends off its humor by divers channels to the before-mentioned cavities. Now if there be ducts or foramina leading into that tissue, then on the other hand in the tissue itself we have a grand and general duct, identical with the whole continuous line of its cells and interstices; and it is perfectly clear that this is as permeable as if it were a downright tube, for when either fluid or air are thrown in, they run entirely through it; which could not possibly be the case without it were able to carry off the liquids discharged into it by any gland, and enclosed within it, by a similar course and circle. It has been satisfactorily shewn by the researches of many anatomists, that the thymus is surrounded with a continuous tissue of the kind alluded to, and consequently that this tissue is a sort of common duct, that leads both into the cavity of the pleura and into the cavity of the pericardium. Thus first, a similar tissue separates the two pleuræ where they form the mediastinum, in which the thymus gland is inserted, as declared by Winslow: "The cellular portion of the pleura," says he, "connects the membranous portion to the sternum, ribs, and muscles; to the

through its foramina, and so through its internal coat in all directions, to the parenchyma of the heart (*i*), where, consti-

diaphragm, pericardium, thymus gland, and vessels. . . . It likewise insinuates itself between the laminæ of the duplicature of which the mediastinum is formed, and unites them together" (n. 415). A similar tissue is also continued from the mediastinum around the pericardium; as stated by the same Author: "The external lamina, or more properly speaking, the common covering [of the pericardium]," says he, "is formed by the duplicature of the mediastinum. It is connected to the proper bag of the pericardium by the cellular tissue of that duplicature" (n. 417). Thus, I think, we cannot possibly be deceived in tracing the derivation of this glandular humor, by closely following the above tissue all the way to its openings and places of outlet; and we have now to shew that these are to be found in the pericardium.

(*i*) From this cellular circumference of the pericardium there is a passage through innumerable foramina into the cavity itself, much in the same manner as in various other members and organs, for instance, the stomach and intestines, in which, as in the present case, there are intermediate muscular layers, athwart which the cellular tissue conveys its little tubes or passages: and in truth, the moving fibres, or if you please, while we speak of the pericardium, the tendinous fibres, alternately open and close the passage, and advance and determine the fluid. Respecting the perforations of which we are now speaking, Malpighi says, "When it [the internal membrane of the pericardium] is compressed, an almost innumerable quantity of minute drops gush from particular orifices on its internal surface. I have found this a constant phenomenon, both in the human subject, in birds, oxen, and all the quadrupeds I have had an opportunity of examining. . . . The pericardium when compressed will often yield little drops of this liquid for as long a time as two days after death" (n. 418). And Winslow says, "The internal lamina [of the pericardium] is perforated by an immense number of imperceptible holes, through which a serous humor continually transudes, in the same manner as from the internal surface of the peritonæum" (n. 417). We may also obtain further evidence from the fact, that a quantity of fluid often appears after death, which has oozed from these little openings, and collected in the cavity; that is to say, from the humor contained in the cellular tissue, and continuing to be squeezed out in the last struggle of life, and thus increasing in amount in one place, in the course of time being forced to its outlets, where the duplicatures unite. This could not be the case unless the humor were supplied by a very extensive tissue. "This humor," says

tuting the liquor pericardii, they anoint the fibres and coronary vessels,—the vessels adorning or crowning the heart's circumference (*k*). It likewise performs the same office of inunction for the trachea, and by filaments continuous therefrom, for the œsophagus, the carotid arteries, the jugular veins, and the great nerves; and this, by means of its jugular or suprathoracic arm (*l*). This extensive gland, the thymus, completely overhangs, and stands at the head of, these its great cavities and members, maintaining precisely the same relation to them in these respects, as the arytænoid glands maintain to the larynx; the thyroid gland, to the trachea; the bronchial glands, to the pulmonary pipes; and numerous other common glands, [to other parts]: all which glands, like the thymus, although un-

Winslow, "gradually collects after death, forming what is called the liquor pericardii, a certain quantity of which is generally found in recent subjects" (n. 417). The same remark is made by Malpighi (n. 418).

(*k*) This liquor must necessarily be instilled or insinuated gradually and imperceptibly through the foramina of the internal coat of the pericardium, and cannot be sprinkled about immediately over the cavity in a vapor or dew, as it were in the form of drops, as might at first be imagined. For as this effluvial sweat goes in through foramina, it will have to skirt along the walls of the above coat, and follow their track, and be carried away in the stream of motion, until it comes in contact with the parenchyma of the heart, or the coat of the great vessel, which it climbs, and thus pours itself around over these bodies. That the internal coat of the pericardium is continuous with the external coat of the heart, and its great vessels, see Lancisi, n. 419, and Winslow, n. 417. But I shall pursue this subject further in what follows.

(*l*) The same condition obtains here also; namely, that as the humor of this gland is derived through the pores and foramina of the pericardium, along its concave surface, to the surface of the heart and its great vessels, as well as around the lungs, so is it likewise around the trachea, consequently, following the continuous lines of the filaments, also around the œsophagus, and the nerves and vessels of that region, which latter, indeed, it sometimes covers in the neighborhood of their bifurcation. But be it observed, that it creeps only around the surfaces, and anoints them, but not into the substances and cavities, since it is merely an external unguent.

provided with visible excretory ducts, being surrounded with a permeable and porous tissue, take a survey from the summits of their respective organs, with a view of providing for the wide horizon of circumferences and gyres that lies outspread beneath their feet (*m*).

436. This gland is continually pouring and excussing its sweats into the surrounding porous tissue, but in quantity proportioned to the activities, as excitative causes, of the viscera among which it is thrown, and to which it is devoted; a large quantity (*n*), when the heart is in an unruly condition, throbbing and palpitating with vehement action; when the lungs, impetuous and boiling, dash against the interposing dyke of the mediastinum, and beat and shake it with the windy tempest

(*m*) The reader will find these particulars mentioned above (*h*). They furnish the chief means whereby we are instructed and convinced respecting the use and office of this great gland. Respecting the arytænoid glands it was before remarked, that, "in order that the glands of the arytænoid cartilages, . . . which glands are peculiar and proper to the larynx, may pour forth the precise quantity of lymph that is actually wanted and desired,—the quantity exactly proportioned to the exercise undergone in singing and speech,—they are placed in close connexion with those cartilaginous joints, moving fibres, and bands, which are perpetually vibrating, and living in action and modulation. And in order that they may distribute their streams equitably, according as they are required, to every point of the circumference of the tube, they are placed in the top or head thereof, and in the cone of the ægis of the epiglottis, and the lymph flows out by invitation, through conspicuous pores, into the cavity of the tube" (n. 366). And something similar was observed of the thyroid and bronchial glands (n. 381). Respecting the latter Winslow says, "At the angle of the first ramification of the trachea we find . . . certain . . . glandular bodies, of a bluish or blackish color, and of a structure very like that of the thymus and thyroid glands. There are other glands of the same kind at the origin of each ramification of the bronchia. . . . These glands are connected immediately to the bronchia, and covered by the interlobular substance" (n. 369).

(*n*) As was observed above in the Chapter on the Lips, the Mouth, the Palate, &c., n. 70, in speaking of the salivary glands,—the parotids and others,—which pour forth an amount of saliva proportioned to the amount of excitation or irritation.

shut up in their æolian bags: and when the trachea, the œsophagus, the great artery, and the vena cava, are in a similar uneasy state (*o*). Hence in order to prevent this gland from pouring all the waves thus called forth, and all the showers thus excussed, into the cavities that it overhangs, the downpour thereof is carried round through the uninterrupted passages of the cellular tissue, consequently through all the septa,—the mediastinum, the diaphragm, and the pleura. And no greater quantity is brought or intruded into the cavities of the breast, the heart, or the throat, than the viscera imperatively demand, attract, and invite, according to their momenta and degrees of motion, and to the law of use and necessity (*p*). In order to provide an asylum for the superfluous humors, this cellular tissue, pervious everywhere, is carried uninterruptedly both to the centres, and to the radii and circumferences; in short, around the pericardium, the lungs, the pleura, and the diaphragm, as well as to the more general receptacles between the laminæ of the mediastinum (*q*). These viscera demand from their gland

(*o*) For the thymus gland creeps up from the chest along the trachea, which is agitated in correspondence with the pulmonic motions, as well as at the same time [directly], by innumerable other motions. It also lies upon the aorta and vena cava, which leap and toss in correspondence with the pulsations and surgings of the heart. By the motions of all these parts, with which it is connected and nearly implicated, it is excited, as by so many external causes, to pour out its unctuous saliva.

(*p*) These points have been proved in our analytical expositions of the several viscera; for unless the influx of humor into the cavity of the pleura and pericardium depended upon a kind of invitation, or to speak more literally, upon physical attraction, the whole animal economy would in fact go to wreck: the heart would receive either too little or too much liquid within its cavity: on the other hand it is clear, that the just and proper quantity always flows in; and this, in the ratio of the cardiac vibrations and pulsations. The same would be the case with the lungs within their cavities; and with the viscera of the peritonæum within the abdominal cavern. Wherefore the law of invitation, so often mentioned above, is universal in this kingdom. The natural means by which it is realized have also been shewn repeatedly.

(*q*) To wit, lest the lungs, the heart, and the trachea, to which the

not only the precise quantity, but also the precise species and quality of liquid, that their nature dictates and requires. Thus

thymus is connected by the cellular tissue, should be obliged to receive all the fluid strained from this gland, and squeezed out by the violence of the motions; in which case, the cavities would be inundated, and the viscera enclosed in them wrecked and sunk, as indeed actually happens in many instances of morbid deluge. Thus Malpighi says, "When the above humor is in a morbid condition, the rhythm of the heart's motion is destroyed; and lately, in examining the body of a patient, who had had vibration and tension of pulse, and a sensation of distress at the heart, two pounds of turbid fluid were found in the pericardium" (n. 418). To prevent these disasters, matters are so arranged as that this fluid can be conveyed away in another direction; namely, into the continuous and uninterrupted cellular tissue extended around the whole of the pleura; which tissue runs without a break from the duplicature of the mediastinum around the pericardium, all the way to the boundaries by which it is united to the diaphragm: hence by this plane there is a way out into the pleura. Thus the heart is not obliged to admit all the secretion of the gland that runs through the cellular tissue of the pericardium. Besides these and several other paths leading into the pleura, there is also a kind of royal road leading towards the external surface of the lungs. And in addition to all these channels for the discharge of superfluities, there is also one very large and palpable channel towards the two pleuræ and the diaphragm, to wit, the great fissure between the laminæ of the mediastinum, which seems in some measure to perform the office of a receptacle; in order, perhaps, that if the pleura itself be distended to the full, or be not in a state to receive more, it may refuse the superabundant afflux. Eustachius has delineated this fissure or cavity, (so Winslow informs us,) and Heister thus describes it: "Between the two membranes of which this double membrane [of the mediastinum] is composed, there is a cellular interstice of considerable size; 1, in the part nearest the diaphragm, in which inflammations and abscesses sometimes occur; and 2, in the upper part of the thorax where the thymus gland is situated... I have found it [the interstice] constantly present, not only in the upper part, but also in the part next the diaphragm; and this, although the sternum be raised as gently, and as little, as possible.... In a public demonstration which I gave in the year 1730, I shewed a case in which this interstice was so large, that the right membrane of the mediastinum adhered to the middle of the sternum, while the left adhered only to the cartilages of the ribs on the left side. It may be added, that various writers relate

the heart within its pericardium demands one species, the solicitation taking place by means of the internal coat of the latter, which for this end is adherent and intimately connected to the heart, its fibres, the coronary vessels, the auricles, and the great arteries and veins (*r*). The lungs within their pleura demand

instances of abscesses and pus formed therein; and J. I. Mayer, a recent author, affirms that he has frequently found it to contain *serum*" (n. 411).

(*r*) I shewed throughout in Part I., in treating of the Viscera of the Abdomen, and shewed, as I imagine, by solid arguments, that not a drop of fluid, however minute, can flow into the bed of any organ, without the organ itself inviting it, and determining not only the quantity to be supplied, but also the quality. In a similar manner a particular quantity and quality of liquid is invited by the heart, by means of the pericardium; as is proved by the supply being always adequate, and always exactly correspondent to the heart's activity: also by the character of the liquid, in that it is found to be nearly the same in all healthy subjects. At first sight, indeed, it would appear absurd to suppose that the heart, so distant as it is from its pericardium, should still be enabled to attract from the gland a quantity and kindred quality adequate and proportionate to its own motion and nature: yet if we duly consider the connexion of the heart with the pericardium, we shall clearly see the proximity of the causes. For the internal coat of the pericardium is reflected to the surface of the heart and its great vessels, and covers that surface entirely; nay, penetrates to the intimate structures, according to Lancisi,[x] communicating with all the nerves and vessels, and proximately with the coronary vessels. This thin internal coat of the pericardium, and external coat of the heart, during every vibration of the heart and its great vessels, is twitched up about the base, the pulmonary artery, the aorta, &c., and solicited to impel, invite, and admit, the liquid circulating through the cellular tissue of the pericardium. This same coat it is that is perforated by the foramina through which these discharges are let in; thus it is this coat that regulates the supply of the fluid. Adherent thereto is the muscular or tendinous fibrous coat, and this cannot fail to comply with the invitation of the former, and to open the doors for the humor to flow in from that moist and ever dripping tissue. I am very confident that this is the rationale of the insinuation of the liquor pericardii into the cavity of the pericardium, unless I admit that I am deceived by positive verisimilitude, and by the progressive series of causes, seen, as it is,

another species, their claim being made by means of their external coat, which for this end goes round the lungs, and softly encloses their great blood-vessels and air-tubes. The trachea again demands a third species. This is the reason of the prolongations, lobular intersections and tuberosities of this gland (*s*).

437. But in the primeval or ante-natal time, in the mother's womb, when the body was at peace, and the temple of the two-faced Janus of the lungs was shut,—when the brain was constantly in the effort to produce, and the heart was wielding the government of the kingdom by compact with the brain, its prince; then this gland was in its pride and pomp, distinguished alike for its goodly size, its comely appearance, its virgin paleness, its delicious softness, and its milk-white juice (*t*). But far otherwise was the case when these halcyon days were gone,—when the gates of this temple of Janus were opened,—the tracheal pipes unlocked,—and the lungs rose insurgent with their wind upon the mediastinum; then the thymus gland, exasperated with so many new and vehement assailant motions, could not fail to pour forth copious spume, contrary to its ancient custom; so that unless it took in sail, and lessened itself, it must overwhelm the caverns of the breast, heart, and neck, with inundation and a deluge. For a small, slight, and disregarded gland, if harshly provoked, pours forth saliva with as much prodigality and freedom, as a large and considerable gland that is treated with mildness, and lying undisturbed and even. Thus in proportion as external motions and impulses increase, in exactly the same proportion, the volume, surface, comeliness, softness, and brilliancy of this gland decrease, as well as its correspondent internal exercitation (*u*): for nature is perpetual

with all clearness. The rationale of the insinuation by the thymus gland of the liquor pleuræ that anoints the lungs, must be regarded as similar to the above.

(*s*) See above, note (*c*).

(*t*) See above, note (*e*).

(*u*) These particulars are so plainly set forth at the beginning of the Chapter, that I need do no more than quote from our Authors. "In infants," says Heister, "[the thymus gland is] of a pale, fleshy

in her measures, proportions, and rules, and her government lies in equilibrium and equation.

438. As life is advancing through its several stages to its closing period, and its attendant irregularities and excesses are committing their devastation, a great number of glands take root here and there upon the pleura and the pericardium (*x*);

color, but of a more dusky hue in adults. . . . It decreases gradually during childhood, and almost entirely disappears in adults and old persons" (n. 430). And Verheyen says, "In old persons it [the thymus] is considerably more compact, and as it were wasted, being not only less in proportion, but less absolutely, than in young subjects" (n. 432).

(*x*) The greatest anatomists have been divided in opinion as to the existence of glands in the peritonæum and pleura, as well as in the pericardium: some having taken the negative side, others, the affirmative; very probably, because glands have been observed in many subjects, while in other subjects few or none have presented themselves; making it equally unsafe to adopt either opinion without bringing the matter to an issue, in which case sight or ocular demonstration is the only standard appealed to for decision. Malpighi clearly pronounces for glands in the pericardium, and classes the pericardium altogether among glandular bodies. "The pericardium," says he, "is a gland, or glandular body, and constantly secretes a peculiar humor" (n. 418). He has also given an elaborate account of a glandular pericardium that he met with in a young subject. *(Ibid.)* And Lancisi says, in the same strain, "In all the subjects which I have examined for the purpose, [both healthy and the reverse,] I have found a number of glands upon the pericardium. . . . These glands are imbedded in fat" (n. 419). He describes also the situation, number, magnitude, &c., of these glands. Heister, on the other hand, although he grants that there are glands in diseased subjects, yet denies their existence in healthy subjects (n. 416); and he likewise adopts the same view with respect to the pleura (n. 411) and the peritonæum (n. 308). But if we look into the matter a little more nearly, we shall find that both opinions are correct; (I am not speaking as an umpire, for I believe both sides); for preternatural corpuscules of the kind, analogous to glands, in process of time are engrafted upon the membranes, upon their folds, and especially upon the cellular tissue, particularly in morbid states, and when life is senile, frigid, decayed, rusted and mouldering; when the skins or membranes that were once elastic, are growing flaccid, and the forces are dying out: at which

for such glands, as we said before, must be accounted preternatural in natural life, but natural in preternatural life, such as human life generally is at this day (*y*). Thus the office of the common or thymus gland is diminished, and distributed and transferred to particular provisional glands, and innumerable lesser glands; so that instead of a continuous quantity, or coexistence of glands in the thymus, we have now the same quantity discriminated or scattered about over the tunics. This furnishes a second cause why the thymus gland diminishes in the middle and closing periods of life, unwinds the thread of its fate, and passes away.

439. But where nature has provided and prepared an influx of humor, she has also provided and prepared an outlet; for if there is a spring, there must be a stream; otherwise the incessant flow would inundate both the cavities. Hence whatever flows into the cavity of the pleura or lungs, the pleura and lungs absorb by their foramina and open orifices; and transmit through the cells of their cellular tissue, either in a circle, or to the skin, or to the bronchia and trachea. There are many circumstances that declare and demonstrate the permeability of the cavity into the pleura and into the lungs, that is to say, inwards; although not from the latter into the cavity, or outwards: as, 1. The presence of numerous openings on the common

time such tubercles may spring up in abundance, even without being induced by disease. According to nature's wonted custom, there are always ducts carried from these adventitious glandular growths, to some particular cavity, by which ducts, the fluid secreted is determined outwards, as in the œsophagus, the trachea, the stomach, the intestines, and other parts. Thus the use of the thymus ebbs away in proportion as similar new springs and rills of humor are multiplied elsewhere. And as it rarely happens in old age that such glands are not planted upon these tunics, and particularly upon the pericardium, it follows that in proportion as this is the case, the use of the thymus is diminished, and its substance and size with its use; while nevertheless, the efficient quantity remains the same, although instead of being a continuous quantity, formed of many glands together in one mass, it becomes a discriminated or separated quantity, scattered about over the tunics. See what we said above on these subjects, n. 427 (*m*).

(*y*) See above, n. 427 (*m*).

membrane of the pleura, and perhaps of the lungs, which membrane environs and secures that uninterrupted passage or cellular duct in both instances (*z*). 2. The conspicuous and continuous determination therefrom, both in a gyre, and to the most external pores, and in this manner out of the body, through the organs of exudation or expiration. 3. The injection of water, oil, wax, mercury, or air, which run uninterruptedly through the interstices of the cellular tissue, and expand and inflate them, but without ever escaping into the cavity; the case being the same in this respect in the peritonæum, in the omentum, in the pleura, and in the lungs [when injected] through the interlobular substance. 4. The actual danger of inundation of the chest, and shipwreck of the lungs and heart,

(*z*) It was shewn above, that the pleura and the peritonæum are perforated by numberless little foramina. Verheyen states that the same is conjectured to be the case with the external or common coat of the lungs. "It is asserted," says he, "by some anatomists, that this [external or common] membrane [of the lungs] has certain orifices or pores, so constituted as to absorb the humor contained in the cavity of the thorax, at the same time that they prevent anything passing from the lungs into the cavity," &c. (*Corp. Hum. Anat.*, tract. iii., cap xii.) But he goes on to say, that he "has neither read nor heard that these pores have been seen by any body" (*ibid.*); and therefore I leave the matter as I find it, and commend the question of such pores to the careful investigation of future anatomists. There is, however, no doubt of the kind respecting the existence of pores in the pleura, the pericardium, the peritonæum, the omentum, and many of the other coverings; and the only question in the case, is, whether the liquor secreted by the numerous arteries of these coverings, exudes through the pores into the cavities, or whether it is absorbed from the cavities; and it seems impossible that this should not be capable of receiving a solution from careful observations. Meanwhile, the arguments adduced are sufficient to convince us, that the determinations are from the cavity, or outwards, and not to the cavity, or inwards; particularly the proofs furnished by the injection of liquids or spirits, and by the inflation of air, into the cellular tissue of the pleura, the peritonæum, the omentum, and into the interlobular tissue of the lungs; the fluid or air distending the parietes, and running through the continuous cells, but in no place escaping outwards; as we observed above in the Chapter on the Peritonæum, n. 325.

not only in dropsy and tympanitis, and other frightful morbid deluges of the same kind, but also during every moment of life, if so copious a secretion were to rush promiscuously through the foramina into the sphere of the principal viscera; an event which nature, residing in her circles, and dreading the fall of her kingdom before its time, has solicitously guarded against beforehand. But this humor is not all thrown out as worthless, but is even gratefully repaid for the use and services which it has afforded to the lungs; for the veins and lymphatics gather and absorb the still useful portion of it, and remit it into the old or sanguineous circle (*a*): the barren and obnoxious portion which these vessels repudiate, they deliver to be evaporated and eructated by the excretory vessels.

440. But the case is different with the liquor pericardii; this does not flow out of the pericardial cavity through the foramina in the membrane, but it flows into the cavity from the cellular surface; for the pericardium constitutes in the chest a gyre within a gyre, and is a circuit of the pleura reflected inwards: thus the internal membrane of the pleura becomes the external membrane of the pericardium, and they both environ their cellular tissue in the same manner; and hence what tends outwards in the pleura, tends inwards in the pericardium. The

(*a*) It is well known from observations, that the pleura is covered and irrigated by numerous little veins as well as little arteries. Heister mentions that it also has "lymphatics, which run to the thoracic duct" (n. 411), and he states the same with regard to the mediastinum (n. 412). According to Verheyen, "Rudbeck figures numerous lymphatics running from the mediastinum to Pecquet's [the thoracic] duct, but which probably do not all belong to the mediastinum, but are some of them running from the neighboring parts, through this membrane, to the before-mentioned duct." (*Corp. Hum. Anat.*, tract. iii., cap. v.) But we shall not stop to accumulate proofs of the existence of these vessels, since they may be readily seen, winding through the cellular tissue, precisely as in the peritonæum. We before spoke of the numerous lymphatics on the surface of the lungs; likewise of the numerous veins, which, indeed, are not so much scattered as heaped together through the whole of their cellular tissue: thus shewing that not a drop of humor can pass by without a tribute being exacted from it by the veins.

mere gyratory form is what misleads us here; for in both cases a very similar determination prevails; namely, from the same common membrane towards the cellular tissue; and from this onwards, in the former instance to the circumferences, in the latter to the centre (*b*). This liquor, according to the law of fluxion in the animal kingdom, that is, in the body of the soul,

(*b*) The determination of the humor of the pleura, as we shewed above (n. 427 *i k l*), is either in a circle through the membrane, and athwart the diaphragm into the peritonæum; or through the conspicuous channels and fissures into the cellular tissue of the muscles, and to the [external] adipose membrane, and so to the skin and epidermis; or else through the cellular tissue of the [broad membranous] ligament, into the lungs: and as the determinations are so numerous, and a determination towards the cavity of the thorax would be contrary to them all, it seems that it would be repugnant or opposed to nature, for the liquor to flow out from the tissue, through the foramina, into the cavity. The same principle occurs in the pericardium, although on account of the determination towards the cavity or sphere of the heart, it appears to be in a manner reversed; but the circuition of the membrane is what leads our first intellectual imaginings into this error; for the same smooth, polished, or continuous membrane which is the internal membrane of the pleura, is the external membrane of the lungs and of the pericardium. The circumvolution and form of gyration, consequently a mere mechanical necessity, produces this effect. This membrane is immediately succeeded by the cellular tissue, both in the pleura, and in the lungs and pericardium; the same membrane being the covering of the same continuous tissue. Hence the determinations remain the same; that is to say, those which in the pleura are outwards, and athwart the muscles of the thorax, in the pericardium are inwards, towards the cavity, and likewise athwart the moving fibres. In fact, the course leading from the circumference of the lungs, through the interlobular spaces, or continuous lines of interstices, towards the bronchia and trachea, must be said to be outwards, and not inwards; for this same direction leads ultimately to the outlets of the lungs. The animal kingdom, as we observed in the Chapter on the Intestines, forms its own proper determinations, which sometimes go in a relatively contrary direction to the determinations of the common or circumambient sphere, from which we derive our notions; but if we only bear in mind the laws of motion, we shall easily extricate ourselves from these physical labyrinths of nature.

tends continually from the region of motion to the region of rest (*c*); and as the region of the greatest rest of the pericardium is the region of the greatest motion of the heart, and *vice versa*, therefore the liquor passing through the foramina, skirts along the internal coat of the pericardium, and keeps close to it, all the way to the triangular spherical centre of the diaphragm (*d*). There the liquor ascends the flat, reclining, and contiguous surface of the heart, and then diffused over its circumference, is carried away there likewise from the sphere of the greatest motion to the sphere of the greatest rest; that is to say, from the apex all the way to the base of the heart, and onwards, around the great vessels of the heart and lungs, into that remarkable cellular tissue that accompanies the sheath formed by the pericardium to the innermost parts of the lungs (*e*).

(*c*) The reader will find this law proved throughout in Part I., as well as in the present Part, and first laid down in n. 42 (*x*).

(*d*) It is pretty generally known, that the proper tunics of the pericardium are agglutinated to the aponeurotic centre of the diaphragm, upon which the flat surface of the heart reclines; and this being the central spot of the whole plane, it follows that it is the most quiet region of the pericardium, which hanging loosely in all other parts, vibrates and fluctuates with the action of the circumjacent lungs, and most of all on the very confines, or about the base, of the heart. That the contrary to this is the case in the heart, we cannot fail to perceive, when we know that the apex is the most moveable part of that organ, and the base proportionably still, as will be shewn more clearly in the Chapter on the Heart. It is not, however, denied, that the vapor is also circumfused and floats about, in the form of a moist atmosphere, around the heart. That all liquids, when intromitted, skirt along the parietes, see n. 352 (*k*).

(*e*) Unless we follow the evolutions of the pericardium with some rational view, we may easily be led to believe, that a barrier is here opposed, by the reflexion of the internal coat, against the humor passing by this way to the intimate parts of the lungs. But as the pericardium encases the vessels of the lungs like a capsule, and accompanies them in the form of a cellular web all the way to their retia [mirabilia], we may conclude how ready the passage thither is, particularly between the two great arteries; especially when we remember that the lungs also bring to bear the invitative power and force of which we spoke in the Chapter on the Lungs. "The pericardium," says Lancisi, "forms

So again the outcast portion of this lymph which is not attracted by the veins or lymphatics, is thrown out through this great and general evaporatory of the sweats.

441. But this extensive, straggling, and erratic gland, in addition to the above domestic and proximate office (*f*), under

a particular capsule that covers and ties down the divisions of the three pulmonary vessels, . . . and is continued all the way to the external surface of the lungs. . . . On the anterior surface, the pericardium will be found to be attached to the two great arteries, and to ascend upon the last segment of the trachea, so as to cover at the same time the bronchial tubes: on the posterior surface it will be observed to be spread under the arch caused by the divarication of the bronchia, and to be firmly connected to them, and to the heads of the great veins. And if we dissect out the surface of the pericardium in the direction of the lungs, . . . and remove a portion of the vesicular substance of the latter, it will be seen that all the pulmonary vessels, both aëriferous and sanguineous, are beautifully environed with the pericardium" (n. 419). And Winslow says, "The trunks of the aorta and pulmonary artery have one common coat [he has just been speaking of the internal lamina of the pericardium] which contains them both as in a sheath, and is lined on the inside by a cellular tissue, that is chiefly accumulated in the spaces where the trunks, and the sides of the sheath, come into mutual apposition and contiguity" (n. 417).

(*f*) The anointing of the parietes of the cavities, and of the surfaces of the viscera of the thorax, throat and neck, is here termed the domestic and proximate office of the thymus, both because it continues to the end of the gland's existence, and because the gland is inserted, affixed and enclosed in the middle septa of those parts. The other offices which it administers, are more general and more remote, and during the subsequent life are assigned and appropriated to other viscera. I allude to such offices as purifying the serum of the blood, which becomes the function of the lungs; presenting the chyle to the subclavian veins, which office is transferred to the mesentery and thoracic duct; and translating the blood through a short circle, from the aorta into the superior and inferior venæ cavæ, which office is committed to the whole of the muscular chest. Meanwhile those few members which at this time, that is, in ante-natal life, hold the reins of government, must sustain a number of offices that will afterwards belong to other viscera. But I foresee that these particulars will not be thoroughly understood by most readers, until we have treated of the state of em-

the government of its nature, or in the uterine state, administered a number of other duties, in conjunction with the brain, the heart, the liver, and the succenturiate kidneys, and enjoyed a kind of rank and prætorship. Thus it was busily employed in the service of all those members which at this time held the administration, as well as of those others, hitherto without a dominion, which were afterwards to come into power. For in this most tranquil state, it required but slight provision to anoint the surfaces of the heart, of the great vessels, the lungs, the trachea, &c., and the parietes of their chamber; and by the unguent supplied to hinder delay in their motions: for the heart and its vessels at this time performed tacit motions, always consistent with nature's rule; and the lungs and trachea, together with the œsophagus, fulfilled as yet no functions, but rested in perfect ease: and nevertheless, the gland was large and tumid; and its space, substance, and supply of fluid were immoderate and disproportioned, relatively to the dimensions of the body in the breast of which it was placed (*g*). Inasmuch then as the thymus at this time, as we said before, was one of the patrician and prætorian organs, let us now proceed to consider its several functions. I. While the lungs were at rest, it secreted a serum from the blood, and thereby prevented any crude or undigested portion of the former from invading and

bryonic life, or the formation of the fœtus in ovo and in utero, which will be the subjects of Part V.; so that they must be only slightly touched upon now; and not passed over, simply because they concern the offices of the thymus gland.

(*g*) We said above, that nature is perpetual in her measures, proportions and rules, and that her government lies in equilibrium and equation. Thus if we contrast the size of this gland with the size of the chest and heart of the little body into the pericardium of which it pours its humor; and furthermore if we consider its soft and succulent character, with reference to the quantity of lymph required within the pleura and pericardium, it will become perfectly evident, that at this time it performed several other functions besides the above: for so large a size, and such humidity and softness appear to be not exactly in proportion to that function singly. Add to this, that the lungs were lying prostrate, and the trachea, moving neither hither nor thither, lived, with the larynx, in the deepest silence and repose.

infesting the brain, the supreme palace of the soul, and the other organs of its diminutive body, superior, middle, and inferior, which were now growing up for future uses (*h*). II. This

(*h*) A number of organs were devoted to the purification of the blood in the embryonic body; on the outside of the diminutive frame, the uterus, the chorion, the amnion, the uterine placenta, the umbilical cord; and in the inside of it, the liver. But since the blood undergoes many changes of state during every round of its circle,—since it is decompounded and compounded, in short, is born, dies, and is born again,—therefore its attendant serum, which supplies and furnishes it with its bodily part, must undergo similar changes, and must be thickened, adulterated, and rendered obsolete; so that without subsequent purification, it would become incapable of returning into the compages of the blood-globule. Moreover, its discharge by the kidneys, and by the general evaporatories, is at this time precluded: and hence it seems absolutely necessary, that it should be purified by organs constructed for the purpose, which are placed close beside the very threshold at which the blood ascends to the cerebrum, and descends to the body,—beside the aorta and the carotid arteries, from which the thymic vessels sometimes derive their blood immediately. See below, note (*l*). Furthermore, the thymus communicates with the mammary, mediastinal and intercostal vessels, in order that nothing may be able to pass by, without this gland attracting it, suitably to its structure and office: for every viscus has the power given it, of summoning either a large or a small quantity of blood from the common mass; and in fact, when necessity is strong, of summoning almost the whole of the blood; so perpetual are the anastomoses:—wherefore I think I am not deceived when I affirm, that every member can demand and derive into it the sanguineous current of the universal body; consequently a quantity that will fulfil any want or use: and this is particularly the case with the thymus gland, placed, as it is, upon the heart, and reaching to its primary entrances. But these very powers of the viscera have their limits; those, namely, which use itself prescribes and determines. Many circumstances contribute to prove, that the above is the function of our gland; to wit, its situation, and its prolongation to the aorta and carotid arteries; the perpetual necessity for the purification as well of the serum as of the blood; the mass of the gland; its extent, softness, succulent and spongy character; its paly and cineritious color, shewing that it does not absorb the red portion of the blood, but the white and serous portion: also the analogous office of the lungs

serum, drawn off from the blood in the intermediate boundary between the brain and its body, and afterwards secreted, the thymus sent forth in a circle, and this, through the mediastinum, the pleura, and the diaphragm; and onwards, through several other coverings, following the continuous fluxion of the cellulated structures, and the line of connexion and communication (*i*). III. Thus it served as a kind of partner or companion in function to the succenturiate kidneys, which attracted this serum circulating through the involucra, and remitted it in a purified condition into the circle of the blood (*k*). IV. But

in the second period of life, (respecting which office, see the Chapter on the Lungs): the series of operations, stated in succession in what follows; for one thing supposes another, and the conclusion establishes the premises, inasmuch as the premises enter and qualify the conclusion.

(*i*) The thymus transmits the superfluous portion of the serosity,—the portion that it does not expend in anointing the cavities or viscera of the chest,—in a circle through the cellular tissue of the pleura; and in fact, of the peritonæum. See above, n. 436, 439.

(*k*) Many anatomists have made the observation, that almost all the humors in the body have their circuits. The most general of these is that of the blood through the arteries and veins. But as the mass of the blood consists of red globules or pure blood, and of a constantly attendant serum, hence this circle is divisible into two, which may properly be termed, general circles. The second of these is the circle of the serum itself, which is principally made, not through the vessels, like the circle of the blood, but through the cellular tissue of the tunics: particularly in embryos, in which the serum serves instead of chyle, and is intended for begetting and generating the new blood. Unless this were of a refined character, it could not possibly enter into coition with the spirit, so as to form the blood;—it could not possibly consummate the marriage. For this reason, as it seems, the thymus is placed above the pericardium, and in the duplicature of the mediastinum, and is prolonged all the way to the trachea; so that it may act as a corculum or little heart for the serum, and maintain its circle. Corresponding to the thymus are the succenturiate kidneys [suprarenal capsules], which lie at no great distance from it, under the diaphragm, and attract and absorb a quantity of the circulating serum from the same involucra or coverings, and after purification, remit it into the sanguineous circle. See the Chapter on the Succenturiate Kidneys,

the blood thrown out by the heart into the great artery, and invited into its neighborhood for the sake of having the serum expunged, and now separated from the more crude kind of serum, it advanced and accelerated into the veins, and thus through brief circles and short cuts, into the inferior and superior venæ cavæ, according to the desires of the heart, the deficiency of blood coming through the liver, and all changes in the mother's state (*l*). V. It prepared and laid down a way for

where the following words occur: "As they [the renal glands] attract this blood from the arteries, so also they attract a large quantity of serum from the cellular coat of the peritonæum, and of the neighboring viscera. . . . This is proved by their place of insertion under the diaphragm; . . . by the permeability of the cellular tissue of the membranes; and likewise of the coats which surround the vessels at this spot; by the fulness of the same in the fœtus, in which these membranes abound in serum, which in the fœtal state serves instead of chyle. . . . Thus the renal glands are constantly maintaining a circulation of the chyloid serum through the cellulated coats of the peritonæum and its viscera; just as the embryonic heart maintains the circulation of blood through the vessels; and they unite this nutritious and richly spirituous liquid to the blood, and remit the product into the sanguineous circulation," &c. (n. 275). Thus the thymus gland and the renal glands should be regarded as the two chambers of a single heart; one of which chambers commences the circle, while the other receives the stream after the circle is completed, and returns it into the gyre of the blood. In confirmation of this, we find that the thymus gland and the succenturiate kidneys or renal glands, have similar destinies, in that they are large, tumid and florid in their infancy, but contracted, emaciated and decrepit in their old age.

(*l*) There cannot be a shorter passage from the arteries into the veins, than in the upper region of the thorax, close to where the aorta issues from the heart, and the superior and inferior venæ cavæ pass into the heart; which shews that the desired quantity may always be supplied to the heart through this channel, by means of the invitation and incitation of the thymus gland. The embryonic state is subject to a number of changes, and with it, the embryonic blood. For the blood has to be derived either from the mass of its own circulation, or through the porta hepatis, from the body of the mother. If haply the maternal fountain be arrested by the affections of the mother's animal mind, or by disease in her body, or if the stream should run too slowly, then

the chyle about to come through the thoracic duct, through its lymphatics destitute of valves, and inserted either into the summit of that duct, or into the subclavian vein; and thus invited, accustomed and inaugurated the blood itself, and the spirit accompanying it from the brains, to the covenant of love, and to the marriage upon which it was afterwards to enter with the chyle of the body (*m*). But these were charges that the gland administered in its truly Saturnian or ante-natal age: but afterwards, when the lungs took upon themselves the office of purifying the serum of the blood, and provoked the delicate compages of the gland with external impetus and stormy motion, extort-

the diminutive body of the embryo must instantly labor under deficiency of the proper supply; in which case, a sudden afflux is provided by the short cut of which we are speaking. Not that the thymus gland transmits this blood through its substance, for it is of a whitish and cineritious color, and invites the serum principally: but since the serum of the blood also attracts the blood itself into its neighborhood, (for the one cannot be separated from the other excepting close to the thymus gland,) therefore the blood is thrown back into the veins, and rapidly into the upper part of the vena cava, and into the right auricle of the heart. "Its blood-vessels," says Heister, speaking of the thymus gland, "come at one time from either the subclavian, mammary, or mediastinal vessels; at another time, from the carotids and the jugulars" (n. 430).

(*m*) According to my proposition, the serum of the blood in the embryo corresponds to chyle in the adult, and the spirit must enter into copulation with this serum, in order that the blood may be generated from it; and hence it is necessary that there be some gland to proffer such chylific essence to the blood of the jugular vein as it is descending with an abundance of spirit from the laboratory of the cerebrum. It will be evident that this is done by the thymus gland, when we consider that its lymphatics are determined to this precise spot; and that those vessels, being destitute of valves, rather resemble ducts than lymphatics. "Its lymphatics," says Heister, "run sometimes to the thoracic duct, at other times to the subclavian vein, and generally speaking, have no valves" (n. 430). The chyle meets with the spirit of the cerebrum in the subclavian vein. See Part I., the Chapter on the Thoracic Duct, n. 162, 166; and the Chapter on the Glands generally.

ing enormous quantities of humor, then the gland, in process of time, abdicated almost entirely these duties of its prefecture, and yielded the performance of them to other members that seized the government of the empire.

CHAPTER VII.

THE DIAPHRAGM.

442. Heister. "The diaphragm is a large, robust, muscular skin, transversely dividing the abdomen from the thorax, and hence called by the Latins, septum transversum. It is situated obliquely, between the abdomen and the thorax; in such a manner, that the anterior and right portion is the higher, while the posterior portion inclines considerably more downwards. Its superior surface is convex; its inferior surface, concave. It is connected with the sternum, the false ribs, the pericardium, the mediastinum, and the lumbar vertebræ. Its figure is commonly compared with that of a racket basket, or of the fish termed ray or thornback; but transversely it is very oblong and elliptical. It has in it two large openings; one on the left side, for the transmission of the œsophagus and par vagum; the other on the right side, for the transmission of the inferior vena cava: and an interstice between the two heads of the inferior portion [lesser muscle], transmitting the aorta, the vena azygos, and the thoracic duct. Its vessels are termed the phrenic, from the Greek φρην, signifying the diaphragm. Its arteries arise, 1. From the aorta or the cœliac artery. 2. From the subclavian or mammary arteries. And, 3. From the intercostal and lumbar arteries. Its veins run to the cava, the vena azygos, and the subclavian vein. Its nerves are, 1. The two great phrenic nerves, arising on each side from the vertebral nerves of the neck, and which are almost exclusively inserted into the diaphragm. 2. Small branches from each intercostal nerve and from the par vagum. Its lymphatics run to the jugular vein. The diaphragm is covered with a membrane, derived on the upper side from the pleura, on the lower side from the peritonæum. Its main body is muscular, of which the superior portion, large and elliptical, arises from the false ribs, from the transverse muscles of the abdomen, and from the xiphoid cartilage; and by its tendon,

produces the nervous centre [centrum nervosum] of the diaphragm, of a nearly triangular figure: the inferior portion has two origins, namely, from the lumbar vertebræ on each side, and is inserted almost into the centre of the superior portion. (*Comp. Anat.*, n. 257.) Tab. iii., fig. 13, exhibits the diaphragm viewed from below; . . . its superior muscle arising by thick fleshy fibres from the sternum and the cartilages of the ribs; which fibres all run towards the tendinous part, like radii to a centre: the inferior muscle, which is in a manner double: the tendinous part, or tendinous centre, to which the pericardium adheres superiorly, and the tendinous fibres of which, as Santorinus observes, decussate and wonderfully interweave with one another for the sake of strength: the transverse elliptical foramen in the tendinous part, through which the inferior vena cava passes: the oblong foramen in the fleshy part, through which the œsophagus makes it way to the stomach: the space or interstice between the two heads of the inferior muscle, where the aorta descends from the thorax into the abdomen; and the thoracic duct, and frequently the vena azygos, ascend from the abdomen into the thorax: also a fleshy portion that existed in this subject in the tendinous portion: lastly, two muscular appendages, which are of a very various shape in different subjects, and are sometimes present and sometimes not. (*Comp. Anat.*, expl. tab. iii., fig. 13.) The uses of the diaphragm, are, 1. To assist in respiration; for it is pressed downwards in inspiration, but upwards, into the cavity of the thorax, in expiration. 2. To further the motions of the contents of the abdomen, namely, of the stomach, the intestines, the liver, the spleen, and of the chyle, the bile, &c. 3. To assist in the expulsion of the fæces and urine, and during parturition, of the fœtus, the secundines, &c. 4. In addition to the above, it also transmits the intercostal nerves." (*Comp. Anat.*, n. 257.)

443. Winslow. "The diaphragm is a very broad and thin muscle, situated at the basis of the thorax, and serving as a transverse partition to separate that cavity from the abdomen. For this reason, the Greeks termed it diaphragma, and the Latins, septum transversum. It forms an oblique inclined arch, the fore-part of which is the highest, and the hinder-part the lowest, making a very acute angle with the back. It is looked upon as a double and digastric muscle, made up of two different portions, one large and superior, called the great muscle of the diaphragm; the other small and inferior, like an appendix to the former, called the small or inferior muscle of the diaphragm. The great or principal muscle is fleshy in its circumference, and tendinous and aponeurotic in the middle, which for that reason is commonly called centrum nerveum or tendinosum. It must not, however, be

imagined that this middle part is of small extent, or that it is round, because anatomists have named it the centre. . . . It is of considerable breadth, and somewhat resembles a trefoil leaf, supposing the part to which the footstalk is fixed, to be hollowed, and that the hollow or slope is turned backward, and the middle convex part forward, and therefore . . . I have called it simply the middle aponeurosis, or aponeurotic plane, of the diaphragm. The fleshy circumference is radiated by the disposition of the fibres of which it is composed, and which are attached by one extremity to the edge of the middle aponeurosis, and by the other to all the basis of the cavity of the thorax, where they terminate by digitations at the lower part of the appendix or extremity of the sternum, at the lower part of the last of the true ribs, of all the false ribs, and at the neighboring vertebræ. We have, therefore, three kinds of insertions; one sternal; twelve costal, six on each side; and two vertebral, one on each side. These last are very small, and sometimes scarcely perceptible. The costal insertions join those of the transversalis abdominis,*. but do not mix with them, as they seem to do, before the membrane that covers them is removed. I need not mention here some communicating fibres of the same kind as those which are found in other muscles, as for instance, between the obliquus externus and pectoralis major. . . . The costal insertions.—The first of these runs a little obliquely on each side towards the cartilage of the last or seventh true rib, and by the obliquity leaves a triangular space between this and the sternal insertion; which space is closed by the meeting of the pleura and peritonæum, as shall be shewn hereafter. The insertion of these fibres is very broad, and occupies about two thirds of the cartilage of the seventh rib, and a small part of the end of the bone, from which it reaches beyond the angle of the cartilage. The second insertion is along the whole of the cartilage of the first false rib: the third, partly in the end of the bone, and partly in the cartilage of the second false rib: the fourth, in the end of the bone, and sometimes a little in the cartilage of the third false rib: the fifth, likewise in the end of the bone, and a little in the cartilage of the fourth false rib, being broader than the preceding: the sixth, or last, is in the cartilage of the last false rib, and almost through the whole length of the bone. At the head of this rib it joins the vertebral insertion, which runs from the lateral part of the last dorsal vertebra to the first lumbar vertebra. Between this vertebral insertion and the second muscle of the diaphragm,

* Winslow says, *obliquus internus* abdominis (Ed. Paris, 1732), but this I have corrected to *transversalis* abdominis, as Douglas gives it in his translation. —*(Tr.)*

a small triangular interstice is sometimes left, like that which I mentioned in speaking of the first insertion. This insertion, and that in the last false rib, join the upper extremities of the psoas and triangularis or quadratus lumborum, and send to them certain communicating fibres. The common plane of these last insertions, by the separation of their fleshy fibres, forms a small hole, through which a bundle of nerves passes. It is to be observed, that the lateral insertions of the great muscle of the diaphragm on the right side, appear to be lower than those on the left side, and that the whole of the right lateral portion of this great muscle appears to be larger than the left, because it is more arched. The small muscle of the diaphragm is thicker than the other, but of much less extent. It is situated along the front of the bodies of the last dorsal vertebræ, and of several of the lumbar vertebræ; and is inclined a little towards the left. It is of an oblong form, resembling a kind of fleshy collar, the two alæ or lateral portions of which decussate, and at length become tendinous toward the lower part. The upper part of the body of this muscle is fixed in the hollow or slope of the middle aponeurosis of the great muscle. The outer edges of the alæ or lateral portions join the posterior planes of the great muscle, and these portions are attached to the body of the last dorsal vertebra. The extremities, which are also called pillars or crura, are attached below to the lumbar vertebræ by several tendinous digitations. The upper part of the fleshy body is formed by a peculiar interweaving of the fibres of the two alæ. These two alæ, of which the right is the larger and the more considerable, part from each other, and form an oval aperture; which is terminated on the lower part by fibres detached from the inside of each ala, immediately above the last dorsal vertebra. These fibres interlace and decussate with each other, and afterwards, those that come from each ala unite with the end of the ala of the other side, so that each of the crura of this muscle is a production of both alæ. . . . Afterwards the crura separate from each other in the manner of a fork. The right crus is larger and longer than the left: it is attached to the bodies of the four first lumbar vertebræ, and often to those of all the lumbar vertebræ, by a corresponding number of digitations, which become more and more tendinous as they descend, and at length are expanded in the form of an aponeurosis. This crus lies more on the middle of the bodies of the vertebræ than on the right side. The left crus is smaller and shorter, and lies more on the left side than on the middle of the bodies of the vertebræ. It likewise is attached by digitations to the bodies of the three superior lumbar vertebræ, seldom reaching lower. Inferiorly it is expanded like the other crus, and the two expansions sometimes touch each other. The oval aperture of the

inferior muscle of the diaphragm, affords a passage to the extremity of the œsophagus; and the interstice between the two crura embraces the aorta. Immediately above the oval aperture, a thin fasciculus of fleshy fibres is detached to the stomach; and I have sometimes observed a similar but larger fasciculus at the lower extremity of the aperture, detached from both alæ, but chiefly from that of the right side, which together with certain tendinous fibres from the left ala appeared to run to the mesentery. In the aponeurotic plane of the great muscle, a little to the right of the anterior part of the slope or incisure, near the small muscle, there is a round aperture, which transmits the trunk of the inferior vena cava. The border or circumference of this opening is very wonderfully formed, by an oblique and successive interweaving of tendinous fibres, almost like the edge of a wicker basket; and is consequently susceptible of neither dilatation nor contraction by the action of the diaphragm. We find, therefore, three considerable openings in the diaphragm: one, round and tendinous, for the passage of the vena cava; a second, oval and fleshy, for the extremity of the œsophagus; and a third, bifurcated, partly fleshy and partly tendinous, for the aorta. The round opening is to the right, close to the upper part of the right ala of the small muscle; the oval or stomachic opening is a little to the left: so that the right ala, which is between these two openings, lies almost directly over against the middle of the body of the eleventh dorsal vertebra. The tendinous fork is under the oval opening, but a little more toward the middle. (*Exp. Anat., Tr. des Muscles,* n. 654—672.)

444. "The left diaphragmatic artery generally arises from the trunk of the descending aorta, as it passes between the crura of the small muscle of the diaphragm. The right diaphragmatic comes sometimes from the nearest lumbar artery, but most commonly from the cœliac. Sometimes both these arteries arise by a small common trunk immediately from the aorta: they are likewise called phrenic arteries. They appear almost always in several ramifications, on the concave or lower surface of the diaphragm, and seldom on the upper or convex surface. They give small branches to the renal glands or atrabiliary capsules, which branches sometimes anastomose with the capsular arteries that come from another part. They likewise send small branches to the fat which covers the kidneys. . . . Besides these principal diaphragmatic arteries, there are others of a subordinate character, which arise from the intercostal, internal mammary, mediastinal, pericardial, and cœliac arteries. (*Ibid., Tr. des Arteres,* n. 172—175.)

445. "Among the anterior branches [of the third pair of cervical nerves], there is one, which being strengthened by an offset from the

second cervical pair, unites lower down with another branch of the fourth pair, and thus forms the phrenic or diaphragmatic nerve. This nerve passes in front of the scalenus muscle, and enters the thorax behind the anterior extremity of the clavicle; receiving immediately afterwards a filament from the first dorsal pair, and communicating with the great sympathetic. It runs down obliquely forwards in front of the subclavian artery, at the side of the par vagum, near the origin of the recurrent nerve. After entering the thorax, the phrenic nerve descends immediately in front of the origin or root of the lung, along one side of the pericardium, to which it adheres, and then running a little backward, it soon enters the diaphragm. It is distributed by numerous ramifications on the great muscle of the diaphragm, sending also some filaments to the lower portion, by which it communicates with the great sympathetic nerve, and with the neighboring plexuses of the abdomen. The right phrenic nerve runs along the vena cava superior, and on that account appears to be placed more anteriorly than the left. This left nerve lies first of all a little backward, towards the trunk of the aorta, and runs a longer course than the right; being bent in order to pass by that portion of the pericardium which answers to the apex of the heart: for which reason it is longer than the right nerve. From thence it curves back, to be distributed to the diaphragm in the same manner as the other nerve." *(Ibid., Tr. des Nerfs,* n. 191—196.)

ANALYSIS.

446. The diaphragm separates between the two regions, namely, of the thorax and abdomen, forming an obliquely transverse partition, made up of three layers, the uppermost of which is the pleura, the lowest the peritonæum, and the middle the proper muscular layer of the septum (a); and since the pleura and peritonæum concur to frame this single plane, it follows, that it is in a manner the conclusion of their works, in which, as in a sum, equation, or simultaneous series, all those things are represented and seen, that take place, one by one, in the members enclosed in the pleura and peritonæum; those things in fact that have hitherto been brought forward in treating of the above members individually: for everything that is done, refers itself to the common coverings, and from them to the diaphragm, there to be concluded, to receive its seal, and to

(a) The first glance at the description of the diaphragm given by our authors, will be sufficient to shew, that it is made up of the two coverings that line the abdomen and the thorax, and that it also consists of a muscular substance enclosed between those coverings. Thus the pleura comes upon this septum from all points of the circumference, and going in continuously to the aponeurotic centre, presently passes to the pericardium, and so returns into its circle through the mediastinum. The pericardium, on the other hand, is adherent to [all] points of its middle or triangular plane. The diaphragm covers itself on the opposite side with the peritonæum, which coming up in like manner to the borders of its circumference, stretches under the entire plane. Hence, in respect of its integuments, the diaphragm is nothing more than the union of the two coverings, consequently, the inter-partition of the two chambers.

find its level (*b*). Inasmuch, then, as this septum is as it were the complement, the last line, and the very union, of all the septa of the viscera, so is it also of all their offices. Now since the indications of these offices are visibly imprinted upon it by many signs, it will furnish an important means of testing the truth [of our Analyses], if we institute an examination at this stage, and in the diaphragm, as a summary of things, consider whether one and the same [general] harmonizes with all those [particulars] that have already been elicited, and brought together from a wide field of materials, in these two Parts of our Work. In this manner let us draw to a conclusion.

417. The diaphragm not only unites in one the common coverings of the whole body; and mediately, through them, their viscera; and mediately again the parts of these viscera, down to the very innermost; but it also unites them immediately, and seals them up with its own seals, by bands detached from its plane, in order that they may all be in ultimate concord; that is to say, immediately, the stomach, the liver, the mesentery, and the [succenturiate] kidneys (*c*); and some-

(*b*) These points will be better understood from the illustrations furnished by the sequel.

(*c*) With respect to the *stomach*, it lies directly under the diaphragm, so that the latter is in contact with it at many points, every time that it undergoes expansion or elevation. Furthermore, the stomach is closely united to the diaphragm by the œsophagus, which passing through the orifice between the crura of the lesser or inferior muscle, flows immediately into its stomach, and serves the same purpose as a ligament; for no sooner has it entered, than it is circumfused over the surfaces of the stomach; and indeed, it even carries down with it a number of moving or tendinous fibres, from the proper substance of the diaphragm. "The oval aperture of the inferior muscle of the diaphragm," says Winslow, "affords a passage to the extremity of the œsophagus. . . . Immediately above the oval aperture, a thin fasciculus of fleshy fibres is detached to the stomach" (n. 443). And again he says in another place, "The first or external coat [of the stomach] is simply membranous, being one of the internal prolongations or continuations of the peritonæum. This appears evidently at the connexion of the superior orifice with the diaphragm, where the external coat of the stomach is really continuous with the membrane

times the lungs; but mediately, the pancreas, the spleen, the intestines, and the bladder (*d*); all of which, it fastens up and watches over, exactly according to the peculiar cause which they undertake in the unanimous society (*e*). But these are external

that lines the inferior surface of the diaphragm" (n. 88). As regards the *liver*, it is conjoined to the diaphragm in the closest bonds by means of a ligament. "The middle ligament," says Winslow, "begins below, in the great fissure of the liver, near the eminences called portæ, and passes . . . to the convex part of the liver, and is obliquely attached to the diaphragm. . . . The liver is likewise connected to the diaphragm, not by ligament, but by a broad and immediate adhesion, without the intervention of the peritonæum," &c. (n. 194). The *mesentery* is in fact brought off from the peritonæum about the lower part of the diaphragm; and in the same place stands its cistern, the receptaculum chyli, and the thoracic duct also there commences its upward course. Respecting the immediate communication of the diaphragm with the mesentery, by means of fibres, Winslow says, "A thin fasciculus of fleshy fibres is detached to the stomach; and I have sometimes observed a similar but larger fasciculus at the lower extremity of the [oval] aperture, detached from both alæ, but chiefly from that of the right side, which together with certain tendinous fibres from the left ala appeared to run to the mesentery" (n. 443). With respect to the connexion of the *renal capsules* with the diaphragm, see Eustachius as cited in the Chapter on the Succenturiate Kidneys, n. 270.

(*d*) Respecting the manner in which these viscera are connected to the peritonæum by ligaments, see the analytical expositions in Part I. of this Work.

(*e*) The reader will find this illustrated in the Chapter on the Peritonæum, where the following words occur: "The members of the abdomen are kept bound and guarded by the general bond of the peritonæum, and by the still more general bond of the diaphragm, closely and thoroughly, in proportion to their priority of place, . . . and to their usefulness in the kingdom; and this, according to the cause which they undertake in the unanimous society. On this account, the stomach, the liver, and the renal capsules, are connected to both bonds in the closest manner; but the pancreas, the spleen and the omentum, not so closely: most closely also, the receptaculum chyli, the thoracic duct, the aorta and the vena cava, the emulgent and spermatic vessels. From this common obligation or bond, that is to say, from the ligaments put forth by the peritonæum and the diaphragm, we may infer and under-

bonds, which the diaphragm puts forth in conjunction with the pleura and peritonæum from the outermost to the innermost parts of the viscera: there are also internal bonds, which, in order that all things may conspire, it transmits and immits by the opposite way, from the innermost to the outermost, so as to meet the former; I mean the nerves of the par vagum, which it conducts along with the œsophagus, between the thighs of its lesser muscle, through the oval orifice formed by their divarication (*f*); and the great intercostal nerves through the crura of

stand, what authority each organ possesses as a member in the empire; and from the influx of blood through the vessels, we may infer what the same organ administers, and what dignity and purple it wears. The organic parts likewise, as the glands, and other similar minute structures in the remote recesses of the several viscera, communicate by capsules, vessels, and nerves, with the common integument, and thereby with the peritonæum and the diaphragm,—each according to the dignity of its cause and office" (n. 321). See also the annotations to the above passage.

(*f*) The nervous fibres and the blood-vessels go all the way to the innermost parts, and weave the organic forms, inasmuch as they are determinant of the universal essences, according to what we laid down above in the Chapter on the Peritonæum: but the very fabrics constructed by them are none other than the organic substances to which the diaphragm, the peritonæum, and the pleura pass, by an external way. At first sight, indeed, it might appear as if the diaphragm and the other coverings flowed in by the same way through the vessels and the nerves, as through the ligaments and the sheaths or capsules, namely, from without to within, for it acts upon the nervous trunks and great arteries, which ramify to the innermost parts. But if we duly remember that the fibres and vessels, in the field of their lesser forms, are what govern their branches and trunks, or invite from them the blood, (as we had occasion to observe in the vascular reticulations of the lungs, and as indeed is the case all over the body,) it will become perfectly evident, that the diaphragm and the common tunics are only the mediate and auxiliary causes of the influx of those essences which are demanded by the innermost parts. Not so, however, the membranes, which proceeding from the diaphragm and the peritonæum, and acted upon in a general manner by the lobes of the lungs, pass uninterruptedly from the surface to the centres: but of these subjects we shall speak at greater length in another place. We treated of the

the same muscle, but which crura exhibit a further opening beside the vertebræ, and decussate with each other as they descend (*g*); likewise the great artery, which it binds down by

passage of the œsophagus and par vagum through the diaphragm, in the Chapter on the Pharynx and Œsophagus, and in the Chapter on the Stomach. "It [the diaphragm]," says Heister, "has in it two large openings; one on the left side, for the transmission of the œsophagus and par vagum" (n. 442). Respecting the manner in which this wandering and erratic nerve descends along the œsophagus, and just above its insertion into the stomach, makes a circular bend, and passing through the [above] opening, throws itself upon the stomach,—lastly, respecting the manner in which, with the great intercostal, it forms the mesenteric plexuses, see the works of those authors who have treated expressly of the nervous system. One thing must here be observed, namely, that the œsophagus, attended by this nerve, passes through the fleshy part of the diaphragm, close to the very origin of the lesser muscle, and where it is most robust, and divaricates into its two crura. From which [passage or] insertion, it appears, that every time the diaphragmatic muscle acts, it exerts its greatest force upon this nerve, as well as upon the œsophagus, but by mere constriction, like the nipping action of a pair of forceps or a fork: and this, for a reason that will be explained presently, in order that it may pour all the pulmonic force upon this nerve, and so upon all its branches; and thus propagate that corporeo-vital motion into the innermost parts of the viscera.

(*g*) The lesser diaphragmatic muscle is at least double, both in its origin, and in its progress and termination; but the two muscles of which it is composed, meet, and decussate and interweave with each other in various places, and in this manner form the apertures through which the nerves and vessels are transmitted, as well as the thoracic duct. It is impossible from descriptions alone to form a correct idea of the separations and connexions between these muscles: the reader must have recourse to anatomical plates; and of all the representations of the diaphragm, the best, in my opinion, is that of an anonymous French Commentator upon Heister [*L'Anatomie d'Heister*, &c., pl. xiv., fig. 1; Paris, 1735],* inasmuch as it accurately expresses the

* The plate to which Swedenborg alludes is found in a French translation of Heister's *Compendium Anatomicum*, accompanied with a Commentary. This work is entitled, *L'Anatomie d'Heister, avec des Essais de Physique sur l'Usage des Parties du Corps Humain, et sur le Méchanisme de leurs Mouvemens. Enrichie de*

the pleura and peritonæum: thus it transmits all those fibres that bring the spirit, and all those vessels that bring the blood, and that penetrate in both cases to the innermost parts of the viscera, and sends them away to the centres (*h*). Thus the diaphragm fulfils all conditions, and carefully provides that the outermost things shall conspire with the innermost, and the innermost with the outermost. Moreover it collects in a manner into one the blood returning from the viscera, and the spirit along with it, and conveys them by two ways into the right auricle of the heart; for it carries the inferior vena cava through a kind of round door in the aponeurotic space, just above the lesser muscle (*i*), and the vena azygos through the bifurcated

minute differences, and particular determinations, of the moving fibres. From this plate, and indeed from the best and most elaborate delineations of other anatomists, we see how the crura of this muscle expand in divers ways, entwine with each other, split asunder again, and ultimately divide into a number of pedicles; and how by this means they fasten with a fibrous embrace upon the ducts passing through them. Besides this most general fastening, the pleura also, and lastly the peritonæum, cover these vessels and nerves.

(*h*) See note (*f*), just above.

(*i*) Certain remarkable phenomena present themselves about the passage of the vena cava through the aponeurotic centre of the diaphragm; I mean, that the diaphragm ties the vein round with a peculiar tendinous circle or sphincter, and after having thus bound it down to itself, carries it onwards towards the right auricle of the heart. This netted crown or wicker texture bestowed upon the vein by the diaphragm, is beautifully described by Lancisi. I shall attempt to give a reason for it in the following pages; meanwhile, I will present the reader with Winslow's description of it. "In the aponeurotic plane of the great muscle," says he, "a little to the right of the anterior part of the

Nouvelles Figures, &c.; 8vo., Paris, 1724; Ed. 2, 1735. The author of it (the "anonymous French Commentator") was the celebrated M. Jean Senac. (See Eloy, *Dict. Hist. de la Médecine*, art. *Senac*, Paris, 1778; and Haller, *Bibliotheca Anatomica*, tom. ii., p. 158, Tiguri, 1777.) He also wrote a *Memoire sur le Diaphragme* in the *Mem. de l'Acad. Roy. des Sciences*, 1729; p. 118—134. The same plate occurs in this *Memoire*, but with a more full and accurate lettering than in the before-mentioned work. M. Senac was the first who discovered and figured (tab. cit.) the ligamenta arcuata externa and interna of the diaphragm: he terms them, arcades tendineuses, and has given a very accurate description of them.—(*Tr.*)

extremity of that muscle; in order that the blood of the former may flow into the right auricle of the heart, below; the blood of the latter into the same auricle, above; and it also gives conduct to the thoracic duct.

448. As the diaphragm is the most general ligament and uniting medium of all the members of the whole body, and of their organic substances, so it is the general directory and uniting medium of all their forces, motions, offices, and uses, in short, of all their accidents; for the fluxion of operations takes place according to the nexus and order of substances; the paths along which operations flow, are determined and marked out by the continuity and forms of substances (*k*). Hence it is, that the diaphragm primarily transmits and effuses the pulmonic actions into the viscera of the abdomen, and into the

slope or incisure, near the small muscle, there is a round aperture, which transmits the trunk of the inferior vena cava. The border or circumference of this opening is very wonderfully formed, by an oblique and successive interweaving of tendinous fibres, almost like the edge of a wicker basket; and is consequently susceptible of neither dilatation nor contraction by the action of the diaphragm" (n. 443). But the vena azygos terminates in the superior vena cava. Thus the diaphragm by these means, [namely, by the vena azygos and the inferior vena cava,] communicates with the whole right auricle of the heart.

(*k*) It is well known that substances are the subjects of all accidents, and that nothing whatever that is referable to the class of accidents, can exist apart from substances by which to flow or proceed. Since then forces, motions, operations and actions, are nothing more than series of accidents and modes, hence they cannot possibly be explored, excepting by virtue of the organic nexus of substances. Thus if we intend to deduce the causes and effects of things from anatomy, or contrariwise, the effects and causes, it will be necessary to follow the organic substances step by step, and at the same time to conceive that there is a series of accidents and motions, consequently of effects, corresponding to the series of substances. I am not at present aware that there is any readier way of investigating this class of truths. Be it remembered, however, that it is necessary to bestow the mind's most concentrated attention upon the nexus of things consecutive and coexistent, and not alone upon the nexus of one series or viscus, but upon those of many series, and in the end, of all.

genital members beneath the abdomen (*l*), by means of its peritonæum; also above itself, into the heart, its auricles, arteries, and veins; and indeed by reaction, into the spinal marrow, the cerebellum, and the cerebrum (*m*): and thus calls together into one, members dissociated in situation, and brings their dissentient wills under one spirit, and in this manner conjoins them. On account of the necessity of this end, and of the effects resulting from it, the diaphragm, 1. Adapts itself evenly and exactly to the concave surface of the lungs, by a corresponding convexity and elevation (*n*). 2. It receives the influx of its lungs, by the mediastinum anteriorly, by the pericardium in the middle, and by the vertebral ligament posteriorly; thus it receives their influx mediately (*o*). As it applies to itself the

(*l*) By the processes of peritonæum that go to the genital members, and of which we spoke in the Chapter on the Peritonæum (n. 321 *c*).

(*m*) This subject was treated of in the Chapter on the Pleura, &c., where it was shewn, that the pleura reacts upon the spinal marrow, to the same extent that it is acted upon by the nerves from the spinal marrow (n. 424, *s*). Something similar may be said of the diaphragm, which is not only attached to the vertebræ, but moreover transmits the nerves of the par vagum, which are nerves of the cerebellum, and receives its own phrenic nerves from the cervicals.

(*n*) We all know that the concave surface of the lungs is adapted to the convex surface of the diaphragm, and sometimes closely, as in brutes. "Their figure," says Heister, speaking of the lungs, ". . . is . . . concave inferiorly" (n. 385). On the other hand, he says of the diaphragm, that "Its superior surface is convex" (n. 442). Hence the applicability of the one to the other.

(*o*) It was shewn above in the Chapter on the Lungs, and in the Chapter on the Pleura, &c., that the mediastinum is connected to the diaphragm in front, immediately behind the sternum; and that the mediastinum passing down around the pericardium, is reflected round the circumference of the tendinous space of the diaphragm, so as to become continuous with the pleura; and likewise that the pulmonary ligament, beside the vertebræ, reaches nearly to the diaphragm. Hence, since the external or common surface of the lungs is continuous with the mediastinum and the pleura, and not only the external [surface] but also the intimate substance of the lungs is continuous with the pericardium, and all these with the diaphragm,—it follows, that the

lungs, that is, the pulmonic actions, by this way, so it applies to itself the actions of the thorax upon the lungs, by another way; namely, 3. By the continuity and the unition of its plane with the xiphoid cartilage, with the seventh true rib, with all the false ribs, with the last dorsal vertebra, and by tendons, with the lumbar vertebræ succeeding the dorsal (*p*): with the lowest muscles of the thorax, and with the highest muscles of the abdomen, and with others that are in action while the lungs are respiring (*q*): these it enters and connects not only with its

lungs are continuous with the diaphragm by this threefold and very ample mediation; and that from this circumstance communications arise, that may be called internal, inasmuch as they are with the lungs themselves.

(*p*) The communication of the diaphragm with the thorax, that is to say, with the ribs and muscles thereof, requires to be closer and more immediate than with the lungs, in order to enable it to perform the office of a general ligament; for the lungs, as was shewn above, are excited in correspondence to every active state of the thorax, and particularly in correspondence to the impulses of the diaphragm manifested in words and sounds, the giving forth of which is almost exclusively the work and province of the diaphragm. Winslow speaks at considerable length of the immediate connexion, or rather continuation, [of the diaphragm to the thorax], "We have," says he, ". . . three kinds of insertions [of the fleshy circumference of the diaphragm]; one sternal; twelve costal, six on each side; and two vertebral, one on each side," &c. &c. (n. 443). And Heister remarks, after speaking of the upper false ribs, that "The anterior extremities of the others [*i. e.* the lower false ribs] are loose and free, lying between the muscles of the abdomen and the diaphragm" (n. 414). Thus not a single part of the costal grate or framework, can be moved, without the effect being communicated in the end to the diaphragm, which receives the last series of motions, and reduces them, as beseems a common ligament, from particular and plural series to a general and single series.

(*q*) That is to say, with certain of the abdominal muscles; with the quadratus lumborum, the psoas; also with the pectoralis, and others. "The costal insertions [of the diaphragm]," says Winslow, "join those of the transversalis abdominis, but do not mix with them. . . . I need not mention here some communicating fibres of the same kind as those which are found in other muscles, as for instance, between the obliquus externus and pectoralis major. . . . [The verte-

pleura and peritonæum, but also with the fibres of its own proper moving life. 4. Not to mention the relationships it establishes with the viscera of the abdomen, by the ligaments, the transmission of the œsophagus, of the par vagum, the aorta, the vena cava inferior, and the vena azygos, and of which we spoke in the last paragraph. 5. To this end may be referred the immediate contact between the pleura and the peritonæum, in the interstices devoid of muscular substance, between the sternum and the [last] true rib, and between the crura and pedicles of its lesser muscle (*r*). All these circumstances prove, that the diaphragm acts entirely under the auspices of the

bral] insertion, and that in the last false rib, join the upper extremities of the psoas and triangularis or quadratus lumborum, and send to them certain communicating fibres" (n. 443). See also the citation from Heister immediately above (*p*).

(*r*) The only inference that can be drawn from this immediate conjunction between the pleura and the peritonæum in the interstices, is, that any action imprinted upon the one, must pass, by means of the contiguity, into the other; and that in this way the diaphragm performs the office of a mediation of the most general kind. The other parts of this plane are closed by the muscular layer. Thus this conjunction or union appears to be instituted, in order that the mediation may not be dependent altogether upon the action of the muscle, or upon the influx thereinto of the nervous fibres. There are certain interstices devoid of the muscular layer, in which the membranes coalesce; one in front, of considerable size, about the connexion of the diaphragm with the sternum and the last true rib, and which is admirably expressed in the delineation given by the anonymous French Commentator upon Heister [*Op. Cit.*, pl. xiv., fig. 1, D D]: and there are other interstices between the divarications of the crura of the lesser muscle, at the places where the œsophagus, the aorta, the vena azygos, and the thoracic duct, are transmitted. "The first of the [costal insertions]," says Winslow, "runs a little obliquely on each side towards the cartilage of the last or seventh true rib, and by the obliquity leaves a triangular space between this and the sternal insertion; which space is closed by the meeting of the pleura and peritonæum. . . . Between the vertebral insertion and the second muscle of the diaphragm, a small triangular interstice is sometimes left, like that which I mentioned in speaking of the first insertion" (n. 443).

lungs, and that it bears sway, as the most general uniting medium, in the universal body.

449. The diaphragm is not only a membrane, but also a spacious muscle, clothed and robed by the pleura and peritonæum, and thus compounded of two natures, of which one is passive, the other active (*s*), and the union of which results in its power intermediate between passive and active, in short, reactive. It derives its active power from the biventral muscle, and its passive power from the tunics covering its two sides. In order that it may distinctly exercise both these, its characteristic forces, it allows itself to be acted upon by the lungs, the muscles, the ribs, and the vertebræ, by means of the pleura and peritonæum; and according to the particulars of this action, to which it is accommodated, reacts by means of its muscle, and of the influx of the phrenic nerve into the fibres thereof. Hence the diaphragm never acts excepting when acted upon by causes arising in the body: thus it concurs with the will in inspiration, and with nature in expiration, and like a spring, regulates, and mediates between, the reciprocations (*t*). For this reason, 1. Its nerves, termed the phrenic, arise from the trunks of the

(*s*) It is well known that the membranes are endowed with a passive, and the muscles with an active power. Reactive power does not result from passive power alone, but from passive and active combined. Hence it will be right to conceive, that the membranes of the diaphragm simply suffer themselves to be acted upon, but not so the muscles. The case is different in the pleura and peritonæum, which although destitute of muscular fibre, still possess the power of reacting. This, however, they derive from their close unition with the ribs, with the costal muscles, and with many of the pectoral and abdominal muscles; also from their arterial networks, which beset the parietes of their trabecular cellular tissue; and at the same time, from the lymph that distends the cells, as we observed in the Analysis of the Pleura. And, indeed, something not dissimilar occurs in the diaphragm; for its cellular tissue, which follows the pleura and peritonæum, is likewise here succeeded by muscular fibre: thus shewing that the same system of causation prevails universally.

(*t*) It would be useless to stop to prove these statements at present, inasmuch as they are involved in the proof of what is to follow, and will be established along with it.

first four cervical nerves, hence also from the trunks of the brachial nerves, and descend behind the anterior extremity of the clavicle into the chest, and afterwards behind the upper ribs, in front of the origin or root of the lungs, and then adhering to the mediastinum of the pericardium, run down into the great muscle of the diaphragm (*u*). 2. The same nerves in different parts of their course, and in the diaphragmatic plane itself, unite with the twigs and fibres of the par vagum and great intercostal nerves, as natural things with voluntary (*x*).

(*u*) Vieussens [*Neurogr. Univ.*, lib. iii., cap. vii., and tab. xxiv., *m* and *] and Morgagni [*Advers. Anat.* v., Anim. xi., ad fin.] appear to agree, that the phrenic nerves do not descend from the brachial nerves, but from some one of the superior cervicals immediately above the brachials. Eustachius delineates them as coming from the first, second and third branches of the cervical nerves, but represents that a small branch proceeding from the fourth cervical nerve, runs obliquely into them as they are passing down. (*Tabul. Anat.*, tab. vii., fig. 1.) Winslow gives the following description of them: "Among the anterior branches [of the third pair of cervical nerves], there is one, which being strengthened by an offset from the second cervical pair, unites lower down with another branch of the fourth pair, and thus forms the phrenic or diaphragmatic nerve. This nerve . . . enters the thorax behind the anterior extremity of the clavicle; receiving immediately afterwards a filament from the first dorsal pair. . . . After entering the thorax, the phrenic nerve descends immediately in front of the origin or root of the lung, along one side of the pericardium, to which it adheres, and then running a little backward, it soon enters the diaphragm" (n. 445).

(*x*) The two sympathetic nerves, or the intercostals and the par vagum, are what we term nerves of nature; the others we term nerves of the will. "This nerve," says Winslow, meaning the phrenic, "enters the thorax . . . immediately afterwards . . . communicating with the great sympathetic. . . . It is distributed . . . on the great muscle of the diaphragm, sending also some filaments to the lower portion, by which it communicates with the great sympathetic nerve, and with the neighboring plexuses of the abdomen" (n. 445). And Heister observes of the diaphragm, that "Its nerves are, 1. The two great phrenic nerves, arising on each side from the vertebral nerves of the neck. . . . 2. Small branches from each intercostal nerve and from the par vagum" (n. 442).

3. They come off almost at right angles from the cervical nerves, in order that the source of their efflux may be mediate from the brains, and not immediate; and that the source of their operation may depend upon the action of the ribs, the lungs, the mediastinum, and the pericardium (*y*); consequently,

(*y*) It is very evident from the plates of Eustachius, Vieussens, and other anatomists, that the phrenic nerves, like two pendulous cords, run down at right angles from the cervical nerves; and are not determined to their destination directly from the spinal marrow as a beginning; also that they describe a pretty long course before they arrive at their stations in the diaphragm; likewise that in their descent they apply themselves to the pericardium, and wind and wander about hither and thither; more especially the phrenic nerve of the right side. The cause of this phenomenon must be sought entirely from the peculiarity of the action of the diaphragm, which peculiarity consists in the fact, that the diaphragm concurs passively to the inspiratory or voluntary actions, but actively to the expiratory or natural actions: for we proved by many considerations in the Chapter on the Lungs, that the alternations of the respiration are at once voluntary and natural. In order to obtain this object, it is necessary that the nerves which govern the muscular forces of this plane, and the modes of those forces, should operate upon the diaphragm in a contrary manner to that in which the nerves operate upon the intercostal muscles, that is to say, upon the thorax: otherwise, the nerves would have passed immediately into the diaphragm, as they pass into the intercostal muscles, to wit, through the foramina between the last dorsal and the first lumbar vertebræ. For the diaphragm in inspiration is expanded in length and breadth, by means of the ribs, the sternum and the muscles, to which it is connected: but in order that it may be contracted again, and return to its pristine and natural dimensions, the muscular force that results from the influx of the nerves into the moving fibres, must necessarily be called in aid; for this brings the operations within the province of nature, which causes this plane, extended by the voluntary actions, to relapse into its pristine dimensions. This view derives powerful confirmation from the experiments instituted on the dog, in which, after the phrenic nerves have been divided, inspiration is performed in the usual manner, but the ribs project very considerably outwards. See the French Commentator upon Heister [*Op. Cit.*, p. 355]. Wherefore the action of these nerves does not proceed from a first cause, that is, not from the cause of the expansion and constriction of the spinal

4. Upon a secondary cause, by which when actuated, even in the dead body, after the manner initiated in the living body, they act upon their diaphragm (*z*). 5. Thus these nerves, depressed and relaxed during the time of inspiration, subject the diaphragm to the disposal of the will, or to the action of the thorax and the lungs; but raised and tightened during the time of expiration, coöperate in their muscles with nature: but this in divers ways, according to the state of government of these two principles, as varied in the actions (*a*). 6. The phrenic ar-

marrow; but from second causes, namely, from causes arising in the body itself; in short, from the expansion and constriction of the lungs: for when the lungs are filled, they are then more closely applied to, and press more forcibly upon, the pericardium, to which these nerves are agglutinated, and hence they relax the nerves themselves immediately above the diaphragm, and so deprive them of all power of operating upon the moving fibres. Not so, however, in expiration.

(*z*) Lancisi demonstrated by a multitude of experiments, many of which we shall bring before the reader in our Part on the Motive Fibre, that when the nerves, and particularly the phrenic nerves, are stimulated by simple contact, friction, or any similar cause, even after death, they operate upon the muscles of their diaphragm, and constringe and expand them. I shall here adduce only a single experimental proof from Swammerdam, bearing generally upon the truth of my proposition. "We observe," says he, "in many animals, that as soon as the beginning of the spinal marrow in the cranium is disturbed, all the subjacent muscles suddenly contract. And this also happens in the same manner with respect to all the twigs of the nerves proceeding from the spinal marrow; at least when they are handled; although in this case only some particular muscles are set in motion, or perhaps only the single muscle through which the irritated twig is distributed." (*Biblia Naturæ*, p. 843.) Swammerdam also states, that he shewed an experiment confirming the latter remark, as applied to the femoral nerves and muscles of the frog, to the Grand Duke of Tuscany, in the year 1658. (*Ibid.*, p. 839.) On this subject, see my *Economy of the Animal Kingdom*, Part I., n. 506, 507, 508; and Part II., On the Coincidence of Motion between the Brain and the Lungs, n. 31, 32, 33.

(*a*) See above, notes (*y*) and (*z*). But the diversities of the influence of these nerves upon the operations of the muscles of the diaphragm, cannot possibly be described, unless the action be previously given or supposed: for they act in one way when the will governs the

teries flowing into the moving fibres, likewise come off from the aorta at right angles. 7. Lastly, animals that are moved to action by the instinct of nature, or by the guidance only of an obscure and blind will, are furnished either with a simply membranous diaphragm, or with no diaphragm at all (*b*).

450. The animal body is a machine, in which nature, governed and inspired by the Supreme Divinity, has brought together and concentrated all her arts and all her sciences: wherefore this machine is made up of mere pivots and centres, which, joined and determined in a stupendous form, in one place constitute axes, in another, radii, and in a third, circumferences; so that there is no point, however minute, of any substance, and consequently no particular of any motion, that is not in some centre, and at the same time in some axis, radius, or circumference: thus this machine is at once a perpetual centre and a perpetual circumference (*c*). But since it is

expirations as well as the inspirations; in another way, when it governs the latter only; differently again in speech, in wrestling, in the evacuation of the bowels or the bladder, &c.; which is the reason of the wonderful connexion between the phrenic nerves and the branches of the par vagum and intercostal nerves. If we allowed ourselves to expatiate into particularities in this place, we should indeed be lost in the unbounded field.

(*b*) In some animals the diaphragm is simply membranous, and in birds it is entirely wanting, its place being supplied by certain muscular fibres. See the French Commentator upon Heister. [*Op. Cit.*, p. 355, 357.] From this it is clear, that the diaphragm is a septum possessing only a reactive force: but in some human actions, its active force overcomes its passive, and *vice versa;* which is the reason why the phrenic nerves are inserted into the muscles in the above manner.

(*c*) At first sight, these statements will perhaps appear a little involved or abstruse; for instance, when we say, that there is a machine that is made up of mere centres: and they cannot fail to look like positive absurdities to those who do not extend their mental sphere beyond the circular form or measure, in which they contemplate only a single circumference, and a single centre, upon which the points of the circumference fall by rectilinear radii. But such form, or rather figure, has no aspiration to perpetuity; for what flows as perpetual in such circumference, is terminated as fixed in the centre itself; wherefore this circular form cannot possibly be the most perfect of all forms, because

composed of forms within forms, and of series within series, standing in an everlasting and uninterrupted relation to each other, hence there are central determinations, or axes and radii, of the simple substances, and of the composite, and more composite substances; or if you please, for it amounts to the same thing, there are axillary and diametral determinations; particular and general (*d*). The most general axis of the whole body is the œsophagus, which passes down from the ultimate pole, that is to say, from the junction of the lower jaw with the tongue and the palate, through the cavity of the thorax, into the arthrodial or inferior muscle of the diaphragm, and continues its axillary determination, and expands it around the stomach (*e*); and contracts it again about the pylorus, and prolongs

it does not aspire to perpetuity. Hence there must necessarily be a higher and more perfect form, which I denominate the perpetual-circular; nay, there must be a form more perfect still, that does not respect any centres as fixed, or any centres in which the motions, and the circumferences, terminate; but centres by and through which [the motions and circumferences] are promoted continually; which is brought about by perpetual gyres, the beginnings of which coincide with the ends. Such is evidently the form of fluxion of the purest entities of nature, from which the perpetuity of motions is derived. But I purpose drawing up a particular Doctrine on the subject of these Forms in the series of the following Parts.

(*d*) As for example, the osseous vertebral column, each vertebra of which is a centre to its particular rib, which like a lever runs out from it to its circumference; and yet all these vertebræ, as so many centres, form a kind of column. The same is the case in all the other parts [of the body], and in fact, more perfectly in the more minute parts, in which the higher forms prevail. This is the reason why, in the animal kingdom, we never can arrive at an end that is not at the same time a beginning; or that is not in some centre,—according to our ideas, an ultimate centre,—and yet at the same time is a point of some radius, as well as a point of some circumference. Hence it is, that the animal kingdom is the last, consequently in a manner the central, work of creation, consisting of mere centres, whereof the first refer themselves to the last, and the last to the first. In these perfections then, although still as it were afar off, and through lattice-windows, we may admire and venerate the infinite wisdom and providence of God.

(*e*) The reader will see the same points laid down in the Chapter

it through the intestines, all the way to the rectum and anus, the ultimate goal of the body. The most general axillary plane, transverse to this longitudinal axis, is the diaphragm, which divides between, and distinguishes, the levers, wheels, and tympana of this machine, in the manner of a general hypomochlium or centre of motion. The consequence is, that the general centre of the whole body, that is, of its viscera and of their motions, is situated exactly at the spot where the œsophagus meets the diaphragm; in short, at the oblong or oval foramen, through the middle of which the gullet runs down from the breast into the chamber of the abdomen (*f*). In order that the longitudi-

on the Pharynx, the Œsophagus, &c., as well as above, n. 447 (*c*): and he will also find it stated in various places, that the stomach is in a manner an axis in peritrochio, and in that character excites the viscera of the abdominal cavity to action; for all these viscera derive from their stomach and intestines those materials that they convey to the blood.

(*f*) We term this the most general axis of the body. There are innumerable other axes besides; for instance, the special axes of the respective viscera; there are also the axes of several viscera, or of one series; but they all respect the œsophagus as the general axis. In order that the œsophagus may act as the axis, not only of the chest, but also of the abdomen, and of the viscera of both, it is necessary that it be transmitted through a peculiar muscle,—through a muscle specially arranged for it, and which in fact is separate from the grand muscle [of the diaphragm]; for the latter applies itself principally to the viscera of the abdomen, and not so much to those of the thorax. Wherefore, in order that the motions of both regions may harmonize, this [lesser] muscle is inserted completely behind the other, and is at once conjoined with it, and separable from it; as may be best seen by a careful examination of the figures that express these two muscles. For the viscera of the abdomen are carried away not only by their ordinary motions, but at the same time by extraordinary motions; for example, when the œsophagus is swallowing, the stomach digesting, and the intestines and the bladder evacuating their contents; and it is quite necessary, for the purpose of preventing these motions from destroying the animal economy, that there should be a muscle that can accommodate itself to the viscera of both regions. "It [the small muscle]," says Winslow, "is of an oblong form, resembling a kind of fleshy collar, the two alæ or lateral portions of which decussate, and at

nal axis, or œsophagus, may also carry with it the most general motions of the body,—I mean, the pulmonic motions,—and distribute them round all the abdominal viscera, at first starting it is tied up to the larynx, in its further descent it is applied to the trachea, adjoined to the bronchia, begirt with the mediastinum, surrounded by the par vagum, inserted into a peculiar muscle belonging to the diaphragm, attached to the fibres of the diaphragm, and then sinks into the stomach, and there becomes an axis as it were in peritrochio, which turns round it all the little wheels, and marks out and arranges their offices (*g*). This axis, the œsophagus, serving these purposes, is met by the transverse septum by way of the circumference, and by means of ligaments detached from itself and from the peritonæum, that septum goes, with the breath of the lungs everywhere accompanying it, both to the surfaces of the viscera, and by capsules or sheaths to their innermost parts, in fine, to a perpetual meeting with the axis (*h*): and thus with concentrated forces, it compels everything that comes under the definition of animal organic to yield compliance and obedience.

451. The diaphragm, thus supported in the most general centre,—in the centre of the viscera and motions of the whole body,—by their axis, the œsophagus, is stretched around as the general ligament, fulcrum, balance, and centre of motion, of all, to sustain their weights, motions, and assaults, on both sides, and to reduce them to a kind of ultimate. For this purpose, in fixing its boundaries, it connects them with all the boundaries that nature has appointed to its body, that is, to the

length become tendinous toward the lower part. The upper part of the body of this muscle is fixed in the hollow or slope of the middle aponeurosis of the great muscle. The outer edges of the alæ or lateral portions join the posterior planes of the great muscle. . . . The upper part of the fleshy body is formed by a peculiar interweaving of the fibres of the two alæ. These two alæ . . . part from each other, and form an oval aperture. . . . The oval aperture . . . affords a passage to the extremity of the œsophagus," &c. (n. 443).

(*g*) See above, note (*e*).

(*h*) This subject was explained in the Chapter on the Pleura, the Mediastinum, &c.

middle thereof; namely, to the ensiform cartilage of the pectoral shield or sternum, to the last of the ribs of the breast, to the projections of the succeeding ribs, to the fascia alba of the abdomen, and to the last of the dorsal vertebræ. While the diaphragm by virtue of these its boundaries sustains the several parts, it also equilibrates them, and limits the sallies of the will within the circles of nature; that is, it expands or contracts these circles, according to the state of wakefulness of the animal and rational minds, and thus adapts the state of nature to the condition of the will; but at the same time it takes care that the voluntary efforts shall not overstep the boundaries prescribed by nature; wherefore it replaces and restores those boundaries every time the will relaxes (*i*). In this way, the transverse septum concurs as a general means of government, in general, with nature and with the will, and at the same time in every particular, with the powers, forces, motions, and actions of both; and constantly equilibrates all their inconstancies (*k*).

452. The muscles that separate the tunics of the dia-

(*i*) It has been shewn before on several occasions, that the body is kept at a certain level, either expanded or constricted, during the waking state, and thus in readiness to obey every intimation of the will: such is the case with the brain, with the lungs, and with the muscles. This effect is communicated in an especial manner to the diaphragm; for the diaphragm is connected to the middle boundaries of all parts, and holds all together in their situation, by virtue of its office as a general ligament: hence when the diaphragm is cut away, the ribs project outwards, according to the observation already cited (n. 449, *y*); which shews that the diaphragm contributes as a principal cause, both to induce and maintain this diurnal state. On this account it not only possesses a muscle that is capable of being expanded and contracted in various ways, but it is moreover hollowed out, in order to enable it to be relaxed and expanded in every direction. By a little attention we may all observe this state of body in our own persons.

(*k*) There are general states of expansion and constriction of the body, which last during the day or the waking hours: but changes of these states happen with every particular action, with every emotion of the animal mind, and with every active force of the rational or proper human mind. If the diaphragm be the means of government of such

phragmatic plane, afford the clearest evidence of the manner in which the forces of the thorax and abdomen act, and of the manner in which the diaphragm reacts, in order that the action may be communicated thereby to the lungs (*l*). The very form of determination of the fibres,—both of the moving fibres of the circumference, and of the tendinous fibres of the central space, affords ocular demonstration upon this point; for the moving fibres are the active forces of the body, the ultimate determinations of which forces are represented by the tendinous

states in general, it must also be the same means in every particular; for particular states constitute the general state.

(*l*) It was shewn above in the Chapter on the Lungs, in treating of speech and sounds, that every action of the thorax upon the diaphragm, passes immediately, as an effect, into the lungs, and their aëriferous vesicles (403, *t* and *u*); so that no particular of an action can exist in the diaphragm, without the vesicular lungs being rendered conscious of it (n. 421). By virtue of this it is, that the auras of the lungs are so wonderfully dispensed in speech, by means of the diaphragm, with respect to both the momenta and to the degrees of the sound. The same thing follows from the contiguity of the diaphragm and the lungs, and from their continuity by means of ligaments. The only doubt that can occur to the mind, is, how so continuous an effect of causes should possibly exist through such numerous and mere contiguities, and if we look at the correspondence of intimates, through mere consecutive mediations. But if we more closely consider the nexus of things in the living body, we shall clearly see, that all ultimate effects are brought about by mere successive mediations; for instance, from the very soul and mind, as well into the sensorial organs, as into the muscles or motorial organs; and that still the effect never fails the cause, although that effect be ever so remote from the first cause. We are only instruments or organs of one life, and from this life, one instrumental cause flows into another, although we can scarcely conceive otherwise than that the last thing is the very first. But we shall speak further of this subject in another place. Similar is the operation of the thorax upon the diaphragm: the diaphragm acts upon the surface of the lungs; this surface upon the air-vesicles themselves, where the effect of the cause exists. That the thorax principally exerts its influence by way of the diaphragm, may be concluded from the experience of Morgagni, who states that the lungs are at no inconsiderable distance from the concave surface of the pleura (n. 390).

fibres. The diaphragm, with respect to its own proper contexture, is a triple and as it were trigastric muscle (*m*). Its first and grand division or muscle flows in by radiated and striated fibres, as it were the semidiameters of the circle, from nearly all points of the circumference, towards the aponeurotic centre, at the margin of which it stops (*n*). Its second or lesser muscle subtends the bottom of the hollow or slope of the aponeurotic space, from which it arises, and dividing into two crura, which again coalesce, and a second time divaricate into a number of little columns, passes onwards to the last dorsal, and the first lumbar vertebra (*o*). The third and least muscle of the diaphragm arises behind the cartilaginous point of the sternum,

(*m*) The muscle of the diaphragm is described by many authors as only a double muscle, and it is said by some, I know not with what propriety, to be a biventral muscle; and thus is distinguished into a greater and lesser; but we shall see presently that there is another little muscle besides, parted off from the great muscle. "It [the diaphragm]," says Winslow, "is looked upon as a double and digastric muscle, made up of two different portions, one large and superior, called the great muscle of the diaphragm; the other small and inferior, like an appendix to the former, called the small or inferior muscle of the diaphragm" (n. 443).

(*n*) This will be best seen in anatomical plates; I mean, that the great muscle passes from its circumference in rays into the whole circumference of the tendinous space; and furthermore, into the inferior slope or hollow of this space, which slope is subtended by the lesser muscle. "The fleshy circumference," says Winslow, "is radiated by the disposition of the fibres of which it is composed, and which are attached by one extremity to the edge of the middle aponeurosis, and by the other to all the basis of the cavity of the thorax, where they terminate by digitations at the lower part of the appendix or extremity of the sternum, at the lower part of the last of the true ribs, of all the false ribs, and at the neighboring vertebræ" (n. 443).

(*o*) "The small muscle of the diaphragm," says Winslow, "is thicker than the other, but of much less extent. It is situated along the front of the bodies of the last dorsal vertebræ, and of several of the lumbar vertebræ. . . . The upper part of the body of this muscle is fixed in the hollow or slope of the middle aponeurosis of the great muscle. . . . The extremities, which are also called pillars or crura, are attached below to the lumbar vertebræ by several tendinous digitations,"

severed from the great muscle of the circumference, and falls upon the very apex of the aponeurotic space (p). The tendinous area itself,—the determination and common centre of the radiated fibres of the muscles,—represents a depressed heart in shape (q). Now these circumstances will enable us to conclude, respecting the particular determination of forces wherewith the circuit or circumference of the middle of the body inflows and conflows into the plane of its transverse septum; namely, according to the various degrees of expansion and constriction of the pleura, the peritonæum, the ribs, the sternum, and the coefficient muscles of the thorax and abdomen; for the diaphragm reacts in the same proportion that it is acted upon, and in the

&c. (n. 443). Respecting the office of the small muscle, see below, n. 453 (z).

(p) Under the cartilaginous portion of the sternum there is a similar muscle, which falls upon the very apex of the spherical triangular space. This is parted from the great muscle by interstices occupied by the pleura and peritonæum; so that it is not adherent to that muscle, either at its origin, or in its course or termination. In fact, in many operations it does not concur with the great muscle; for we have the power of filling the lungs by the elevation of the sternum, or even by its intropression; thus variously, according to inevitable and compulsory determinations. The reader will find this muscle distinctly expressed and delineated in the plate of the French Commentator upon Heister already referred to. [*Op. Cit.*, tab. xiv., fig. 1, F F.] However, as it likewise sends down its fibres, in rectilinear radii, to the aponeurotic space, it is considered as a part, although a distinct part, of the great muscle, and is assigned thereto.

(q) The figure of this aponeurotic space is something like the figure of the hearts upon cards,—something, in fact, like the common idea of the shape of the heart. Its corners are rounded; but its lower side is hollowed out for the lesser muscle. "It must not . . . be imagined," says Winslow, "that this middle part is of small extent, or that it is round, because anatomists have named it the centre. . . . It is of considerable breadth, and somewhat resembles a trefoil leaf, supposing the part to which the footstalk is fixed, to be hollowed; . . . and therefore . . . I have called it simply the middle aponeurosis, or aponeurotic plane, of the diaphragm" (n. 443). We have chosen to term this triangular space or plane, spherical; and it also resembles a centre, in that the forces of the fibres of the great muscle terminate on its surface.

same manner. By the diaphragm, consequently from the collected forces of the thorax and abdomen, a precisely similar action is communicated to the depressed or concave surface of the lungs, and from this, to their vesicular or æolian centres, giving rise to a correspondent inspiration and expiration (*r*). The tendinous space itself, where the moving fibres of the grand muscle, as well as of the least or sternal muscle, place the boundaries of their forces, marks the limits of the influx and conflux of the actions of the thorax and abdomen: for they reach as far as this space in acting upon the lungs, and mutually extinguish each other there by their meeting (*s*). This space lies spread as a pillow under the dorsum or plane surface of the heart, the pericardium intervening (*t*); and thus the heart, like

(*r*) These particulars have been explained above on several occasions; the last instance occurs in n. 448 (*p*).

(*s*) If we consider all the ratios of the forces that flow from the sternum, the ribs, the muscles, the pleura, and the peritonæum, into the diaphragm; and if we compare those ratios with the distances which the fibres measure from the circumference to their respective ends; that is to say, to the spots where the forces or fibres terminate, and as it were die away, (which happens in the periphery of the aponeurotic space,) we shall clearly perceive that the ultimate limits of these fibres cannot possibly produce any circular figure. For in inspiration, the sternum is less elevated and removed than the lowest [true] rib; wherefore the fibres of the sternal muscle flow by a very short passage into the tip of this centre or triangular spherical space. The false ribs expand still more widely; hence the moving fibres that proceed from the points of that part of the circumference, are longer than the others, which are diminished as they reach the vertebræ. For this reason the figure of this space cannot be regularly spherical. The force of the point at the circumference determines the extent of each moving fibre: thus, in the configuration of this plane we have the means of inferring the force, or ratio of forces, with which each point of the circumference acts. But it is also to be observed, that the sphere of the action of the heart as it lies upon this tendinous plane, may also have something to do with the termination of the fibres.

(*t*) "The pericardium," says Winslow, "is closely connected to the diaphragm, . . . exactly at the place which answers to the flat or lower side of the heart: it is so strongly adherent at this spot, that it is very difficult to separate it by dissection. The adhesion extends no

a boat in port, lies in perfect safety in the midst of the waves that the winds of the lungs call forth, and in the centre of its own sphere, washed round by that of the lungs, it performs and seals its reciprocations, and thereby the circles of life of the whole body.

453. But the aponeurotic, triangular spherical space, although indeed the centre of the converging rays of fibres of the grand muscle, as well as of the least or sternal muscle, yet is not the innermost centre of the plane itself; for every space, and therefore the triangular spherical space, has common relation to a particular centre. This centre in the present case is marked by a certain round or elliptical foramen (*u*), through which the vena cava ascends with the blood of the inferior region, and which is situated at the head of the lesser muscle, at the point of intersection of [lines drawn from] the three angles or points [of the triangular space], and above the hollow or slope on its lowest side. The ultimate or intimate fibres encircle and bind this centre, after the manner of a sphincter, as a chaplet of vine-leaves or palm-branches encircles the head of a victor (*x*); and thus manifestly declare that they have reached

further than the limited portion, which is in some measure triangular, answering to the lower side of the heart" (n. 417).

(*u*) This foramen is said by some anatomists to be round; Heister states that it is elliptical. Thus in describing his tab. iii., fig. 13, he speaks of "the transverse elliptical foramen, . . . through which the inferior vena cava passes" (n. 442).

(*x*) Many circumstances tend to prove that the vena cava occupies the most absolute [ipsissimum] centre of the tendinous space; as, 1. The figure itself; for if a perpendicular or line be drawn from each tip or angle to the opposite side, the point of intersection will coincide with this foramen; and this, be it observed, is the usual method of ascertaining the centres of triangles. 2. The direction of the fibres of the great and least muscles, which fibres tend almost unanimously hither; so that if we carry them all out to a common point of intersection, we shall find that they will meet in this spot. 3. The figure of the foramen itself, and the tendinous fibres that like a sphincter encircle and crown this centre. See the description of those fibres, n. 447 (*i*). The case, however, is different with the fibres of the lesser muscle, respecting which, see below, note (*y*).

the goal, where they can crown the vein, escaped from the unquiet field of the pulmonary motions into the more tranquil field of its heart, and lead it by the sympathetic nerves, first to the hall, and presently to the innermost chambers of the heart (*y*). Thus we find two great centres in the plane of the diaphragm; the œsophagus runs down through one, the vena cava runs up through the other: the former is the centre of the sphere of the pulmonary motions, but the latter is the centre of the sphere of the pulses and circles of the heart; and the one returns by wonderful revolutions into the other: and in order to prevent the one from disturbing the circles of the other, the œsophageal centre is begirt by an active muscle of its own, which restrains the great muscle as an antagonist, and governs the plane itself as an axis; wherefore this muscle does not flow into the aponeurotic space with tendinous fibres, but merely connects its dorsum with the slope thereof, by a broad adhesion (*z*). Such

(*y*) See the description given above of the lesser muscle, in note (*f*). At first sight we might easily be led to believe that the lesser muscle is only the continuation of the great muscle, or the appendage thereof; for it is fitted into it laterally, and the two are slightly adherent. But if we consider its origin, progress, and termination, we shall find that this muscle is entirely distinct from the great muscle, not only with respect to its fibres, but also with respect to its modes of operation; and that it arises from the slope of the aponeurotic space, and in fact, from the centre of its fibres, near the vena cava; for it is very robust and large in this situation, and does not communicate with the aponeurotic space by any tendinous fibres. From this its beginning, it afterwards contracts in its progress, and at length divides into a number of pedicles, and finally into several tendons. It is therefore fleshy at its commencement, and tendinous, like other muscles, at its termination. "The extremities [of the lesser muscle]," says Winslow, ". . . are attached below to the lumbar vertebræ by several tendinous digitations. The upper part of the fleshy body is formed by a peculiar interweaving of the fibres of the two alæ. . . . The right crus . . . is attached to the bodies of the four first lumbar vertebræ, and often to those of all the lumbar vertebræ, by a corresponding number of digitations, which become more and more tendinous as they descend, and at length are expanded in the form of an aponeurosis" (n. 443).

(*z*) These considerations not only shew that this lower muscle does

is the influx of the activity of the lungs into the sphere of the heart's activity.

451. The radiated muscular circumference is accompanied and covered on both sides by cellular tissue, into which the diaphragm, by its alternate expansion and constriction, is constantly inviting the lymph through various streams, from the similar and continuous tissue of the pleura, the mediastinum, and the peritonæum (*a*); and it conducts this fluid, according

not flow, like the great muscle, into the tendinous space of the diaphragm, but flows out from it; but they also shew that this muscle, by its action, does not alter the dimensions of the diaphragmatic plane; for it is attached to the vertebræ, which do not expand in the same manner as the ribs. The fact then is, that this muscle begins to act where the great muscle ceases to act, to wit, from the centre of the diaphragm, or the round foramen that lies close beside its head: from this point, this muscle transfers its forces to the vertebral column, and its centre of gravity, which as we before explained, in the Chapter on the Thoracic Duct, in speaking of the receptaculum chyli, exists about this region. Hence this muscle must be regarded as an axis, because it conjoins the three most general centres of the body; namely, where the inferior vena cava emerges; where the œsophagus demerges into the stomach; and where the cistern of the mesentery resides: and this is, indeed, the reason why the vessels, ducts, and nerves pass through particular divarications of its crura. It is evident from this description, that the lesser muscle is the antagonist of the greater, and as it were the column of its ultimate forces; and that it prevents the vena cava from being moved out of its place in any distraction of the diaphragm by the uneven actions of the thorax: for it reacts against all the fibres of the great muscle, inasmuch as it arises broadly from the slope or hollow of the aponeurotic space; its head being almost in contact with the border of the vena cava. "In the aponeurotic plane of the great muscle," says Winslow, ". . . near the small muscle, there is a round aperture, which transmits the trunk of the inferior vena cava" (n. 443).

(*a*) It has been pointed out and shewn above in many places, that the muscle of the diaphragm is covered by the peritonæum on the one hand, and by the pleura on the other, and that a cellular tissue intervenes on both sides between it and those membranes. Let us now simply enquire, through what passages this tissue, and consequently the humor that it carries, flows in from those involucra, and [whither it] is continued. The first way is from the mediastinum, close behind

to nature's constant law, from the peripheries or greatest motions, to the axes and centres, or to the most quiet stations of its plane. Hence it determines the descending lymph of the mediastinum and pleura towards the borders of the aponeurotic centre (*b*), where the mediastinum of the pericardium meets it with its humid tissue: and lest the humor should stop here, in this most quiet centre, and inundate and infest the sphere and bed of the heart and vena cava, the pericardium is closely attached and adherent at this spot, and as it were keeps watch, and carefully guards against any irruption that might otherwise take place. Hence the circumfused liquid is carried away head-

the sternum, where the mediastinum is connected to the diaphragm: in this situation, just above the place of contact of the mediastinum with the diaphragm, a very considerable fissure is observed, according to Heister, from which fissure the cellular tissue runs continuously to the least muscle of the diaphragm. The second way is immediately from the pleura and the peritonæum around the whole circumference of the diaphragm. The third way is from the pericardium, the external coat of which,—a continuation of the mediastinum,—falls upon the diaphragm round about the aponeurotic space, and is there reflected so as to become continuous with the pleura. Corresponding in number are the derivations of fluid from the cellular tissue of the pleura into the diaphragm. And it seems impossible to doubt the existence of a communication through the intermediate muscular fibres of the liquids coming from both regions, when we consider that the same thing obtains almost universally in viscera provided with a muscle; and the more readily in the diaphragm, since its two tunics, the pleura and the peritonæum, are in contact with each other in various places, for instance, on both sides, near the sternum, and below, close to the vertebræ, between the divarications of the lesser muscle.

(*b*) The forces and motions of the fibres of the great muscle terminate at the parietes of the aponeurotic centre, where the moving fibres become tendinous. See above, n. 452. And this centre or space also possesses its own centre, which is the innermost of all, and is situated at the vena cava. See n. 453. If then the liquid has a common tendency from the peripheries and greatest motions, to the centres or more quiet stations, (according to what we now understand to be the general law,) it must evidently be carried off to this centre, and in fact to the innermost [centre], all the way to the round foramen: for which reason this particular space is covered and defended by the proper coats of the

long from its circumferences, where it fluctuates with the motions of the septum, to a haven of rest and calm; that is to say, around the lesser muscle, which restrains the great muscle as an antagonist, and subtends the plane itself as an axis; and afterwards, between its divarications and interstices, to the succenturiate kidneys(*c*). Such is the intercourse that the diaphragm appears to have instituted, during the period of embryonic life especially, between the pleura and the peritonæum, and between the thymus gland and the suprarenal glands.

455. In order that all things may flow to and fro in a constant circle, and that each may be emulous of perpetuity, and describe forms that shall perpetuate the motions of life,—the viscera, cavities, and septa of the organic frame are not precisely equilibrated and sustained by each other in the manner of the well-poised scales of a balance; that is to say, they are not symmetrical, nor of equal force and weight, on the right and left

pericardium, the latter being so firmly connected thereto that it cannot be separated without the greatest difficulty; according to the observation of Winslow (n. 417). Therefore, since the humor is driven from this space, it follows its periphery, from which it is determined by a natural force towards the axis or lesser muscle; and this the more readily, since one side of the diaphragmatic plane is larger and more capacious than the other; so that the humor is urged on thitherwards by the superior force; and here again from the greater motion into the lesser.

(*c*) The thymus gland and the two suprarenal glands are mutual correspondents; that is to say, the thymus gland elects a particular serous and chylific juice from the arterial blood, and throws it out in part into the cavities of the thorax and heart, in part in a circle through the mediastinum, the pleura, and the diaphragm: and the renal glands attract this liquid, and send it back purified into the gyre of the blood. On these subjects, see the Chapter on the Succenturiate Kidneys, and that on the Thymus Gland, n. 441. Hence the above organs communicate with each other by vessels, by means of the mediastinum and the diaphragm; for the mediastinal arteries anastomose with the phrenic, and these, with the vessels of the suprarenal glands. "They [the ramifications of the phrenic arteries]," says Winslow, "give small branches to the renal glands or atrabiliary capsules, which branches sometimes anastomose with the capsular arteries" (n. 444).

sides of the body. Thus the right lobe of the lungs is larger and more capacious than the left; likewise the right cavity of the breast or pleura that encloses the right lung (*d*). The mediastinum behind the sternum is on this account inflected considerably towards the left (*e*). The right half of the plane of the diaphragm surpasses the left half in size and strength; so also the right half of the inferior muscle, with its crura and pedicles (*f*). Again, the heart does not lie exactly in the middle between the lungs, or upon the aponeurotic centre, but pulsates at the left side of the chest, in the opposite direction to the greatest force of the lungs. The stomach does not occupy the middle of the abdomen; nor is its cavity constructed on both sides with an equal arch; nor are its two orifices, the cardia and pylorus, found in the course of the same diameter (*g*).

(*d*) Although these particulars may be known from the foregoing descriptions, it will nevertheless be advantageous to submit a running statement of them to the reader's eye. With respect to the lungs, Winslow says, "The right lung is generally larger than the left, conformably to the right cavity of the chest and to the obliquity of the mediastinum" (n. 387). And with respect to the cavities: "We see, not only that the thorax is divided into two cavities, entirely separated from each other by a middle septum; but also that the right cavity is greater than the left" (n. 415).

(*e*) On this subject, Winslow says, "The mediastinum inclines from above downward towards the left side: and . . . if the middle of the sternum be penetrated by a sharp instrument before opening the chest, there will be found to be almost the breadth of a finger between the sternum and the mediastinum: provided the sternum be kept in its natural situation" (n. 415).

(*f*) "The right crus [of the lesser muscle of the diaphragm]," says the same Author, "is larger and longer than the left. . . . The left crus is smaller and shorter, and lies more on the left side," &c. (n. 443).

(*g*) Again he says, "The stomach is not situated in the left hypochondrium and epigastric region, in the manner represented in most of the figures. It lies transversely, obliquely, and almost laterally; the great extremity and the orifice next to it being to the left, and the small extremity and the pylorus to the right, and lower and more inclined than the former. . . . Thus the body of the stomach is by no means in the same plane with the œsophagus, but forms an angle or fold immediately at the passage of the œsophagus through the small muscle of the diaphragm;

The spleen on the left side does not equal, although with the pancreas it sustains, the weight of the liver on the right side. The vena cava and the aorta, unlike a married pair, do not lie close to each other in their passage through the diaphragm. The one intercostal nerve does not run forth in the chest in the same manner as the other; still less in the abdomen, and in the mesaraic plexuses. As it is in the whole body, so it is in every viscus of the body (*h*). From this disposition of parts, and the corresponding fluxion of motions and circulation of humors, it follows that thus, and not otherwise, does nature accomplish the perpetuity to which her life aspires; and that thus, and not otherwise, does she flow from the equilibrium of one motion into a second motion; for as we have said before,

and on account of this angle, the superior orifice is turned a little backwards" (n. 88).

(*h*) Not to mention the liver, the spleen, the kidneys, the intestines, and numerous members, which are by no means constructed upon the circular law, but have either lobules or other subdivisions that greatly differ among themselves in their size and other attributes. The reason of this is sufficiently evident. For if the dimensions of the two sides were equal, like the two halves of a single circle, ellipse, or oval, then the respects or relations of all the parts would meet in determinate foci or centres, and with the relations, the very efforts and forces: and when in these centres, they would tend no further, but stop. The truth is, however, that the animal machine is so framed, that everything tends to its own centre; from this again, inasmuch as it is placed in a new circumference, to another centre; and so to perpetual revolution: from which circumstances it is perfectly clear, that some form superior to the circular prevails in the living body; some form that never makes a centre as an end, unless at the same time and in the same place as the beginning or principle of a new motion. But lest purely geometrical minds should be disturbed in their circles by my declaration, that there exists a form superior and prior to the circle, and more perfect than it; a form indeed of such a character as to be the measure of the circular form, as the circular is the measure of all triangular forms; and still more when I add, that there exist forms still superior, prior, and more perfect;—lest this should be the case, I have it in contemplation to draw up and prepare a particular Doctrine of Forms. Meanwhile, see Part I., the Chapter on the Stomach, n. 97 (*f*); and the Chapter on the Intestines, n. 130 (*e*).

there are as many centres as points, and as many equilibria as centres; and these, wonderfully continued or connected, form axes, radii, circumferences, and in fine perpetual gyres, which where they enfold themselves in ends, there distinctly unfold themselves from the same ends, as from their beginnings. Machine of a skill oh! how stupendous! Could we but really explore one ten thousandth part of its wonders, we should surely be stricken with holy amazement, and from that ground alone adore the wisdom of the Creator; and the pride of our knowledge and wisdom would not merely subside, but would fall prostrate in self-derision. Yet these are the lowest proofs of His omnipotence, for He has filled the vilest insect with similar miracles.

EPILOGUE.

456. The lungs, in the first flower and golden age of their life, or when the body and the thorax were enveloped and confined by manifold swathings in the mother's womb, were unable as yet to expand, still less to open the mouth of their larynx (*a*): but together with the brains, the heart, and the members attendant thereupon, they passed and beguiled their day, which was nine months long, in the deepest peace, and as

(*a*) Although it may appear sufficiently evident and incontestable at the first glance that the lungs could not have respired in the uterine state, yet it may not be without its use, to confirm even the common opinion by a statement of proofs, for without proofs be given, the minds of some individuals are apt still to remain in doubt. At this time, then, the chest, with the ribs, the sternum, and the muscles, was so bent inwards and compressed, that it had neither room nor power to rise and open out. Besides, the spine of the back was so much incurvated, that it could not possibly, by any living force or expansion, have excited the costal nerves, which act upon the above muscles. Again, there was no surrounding atmosphere which the lungs could have drawn to them, if they had been raised; but instead of an atmosphere, they would probably have imbibed the liquor amnii in streams, and have overwhelmed the bronchial pipes and vesicles, that is to say, would have overwhelmed themselves, in sudden shipwreck. Add to this, that the cardiac blood had not yet flowed in through the pulmonary artery, although this blood alone gives the lungs the power of respiring, as we observed in the Chapters on the Lungs and the Pleura, &c. At this time, the bronchial artery and the fibre of the pulmonary plexus reigned sole and supreme, and might possibly have produced a certain slight vibration synchronous with the movement of the heart.

it were in the temple of concord (*b*). At this time the soul, under the auspices of the supreme mind, by means of the brains and their fibres, and in the ultimate sphere, by means of the heart and its vessels, ruled and governed the helm of the kingdom; it was the only principle of all motions: the determinations from this principle flowed through adopted and organically constructed forms, serving in orderly sequence and manifold succession as first, intermediate, and ultimate causes: hence all efforts, forces, actions, and modes thereof, agreeably to the order appointed by nature, proceeded constantly from the first spheres to the last, or from the innermost to the outermost (*c*).

(*b*) It is evident from the initial stages of the formation of the living body, that the fibre was the first determination of all things therein, that is to say, the first, that wove all the organic forms, and inspired them with active, consequently with motive, force. If this be true of the fibre, of course it follows that the cerebrum in the widest acceptation of the word, or as including the cerebellum, the medulla oblongata, and the medulla spinalis, which are the birth-place of the fibres,—it follows, I say, that the cerebrum was the first thing that excited the machine to its motion; and that all things received their origin, and their principles of motion and progression, under the auspices of the cerebrum, consequently of the fibres thereof. If we grant this, then we must admit that the heart, the secondary principle of motion, was not excited to its reciprocations by any other causes; and, therefore, that the rhythmical movements of the heart were consonant with the animatory movements of the brain, and hence that concord prevailed throughout, so that the vessel never rose in insurrection against the fibre, nor the blood against the spirit, nor, in a word, the body against the soul. But we shall treat this subject in greater detail in the Parts on the Heart and the Cerebrum.

(*c*) We can never arrive at a true knowledge of the animal kingdom, unless we entertain a distinct idea of the subordination and succession of efficient causes, and unless we have a distinct conception of the nature of the prior and of the posterior sphere, or what amounts to the same thing, of the interior and of the exterior, and of the difference between them; for the prior and the interior are also the more perfect and the more universal. The progression from the prior to the posterior,—*a priori ad posteriora*,—or from the interior to the exterior, is identical with the progression from the soul to the body; but the progression from the posterior to the prior,—*a posteriori ad priora*,—or

Thus the body was the body of its soul, and the subject of the auspices of the supreme mind. But when the period of these destinies had passed away, and the mannikin, bursting the swathings and bars of the womb, rushed forth upon the theatre of the great world, the state of life was instantly changed, and the hinges of the determinations, forces and motions were inverted and bent backward against the order of the former life; namely, from the outermost spheres to the innermost, or from the body and its powers inwards, towards the proximate and immediate powers of the principle or soul (*d*). In order that,

from the exterior to the interior, is identical with the progression from the body to the soul. I intend to expound again in the sequel the Doctrine of Order and Degrees, as well as the Doctrine of Influx,* in order that we may have a just intellectual comprehension of the above scale of progression. I will here only remark, that in the uterine life, all active force flowed in, according to truly natural order, that is to say, immediately from the soul into the ultimate forces of the body; but afterwards, in the life after birth, inversely, from the body to the soul; so that what was previously active, thenceforward became passive, and at the same time reactive; just as we observed above of the bronchial artery, in the Chapter on the Lungs, where it was stated that "this artery, in conjunction with the twigs of the par vagum and intercostal nerves, was what conceived, engendered and constructed the embryonic lung, and all its vessels, aëriferous, arterial and venous; and laid down and formed those direct passages along which the atmospheric air and the cardiac blood are to pass and glide in the second period of life: thus this artery was once the parent, but now the change in its fortunes has made it the daughter and the slave" (n. 409). See also *ibid.*, note (*o*). But the reader will find this confirmed by a number of experimental proofs in another part of the Work.

(*d*) If we are able to discriminate distinctly between the outermost sphere and the innermost, we shall clearly perceive that the order is entirely inverted. The outermost forces of the body are the muscles and their moving fibres, which, on this account, have their places in the circumference of the frame: the bones and cartilages also belong to this class of forces. The ultimate or lowest universal essence,—the

* The reader will find these subjects treated of in Swedenborg's "*Angelic Wisdom concerning the Divine Love and the Divine Wisdom*," and in his "*Intercourse between the Soul and the Body*."—(*Tr.*)

after this inversion, the last causes might take the first place, the lungs were opened: the lowest atmosphere of the world was admitted through the nares and the larynx into the trachea and the bronchial pipes: the muscles of the thorax were unfolded: the ribs with the vertebræ and sternum were moved from their places, to and fro: and the reciprocal actions proceeding from these ultimate causes, or from the body, were transferred through the diaphragm, the pleura and the mediastinum, into the innermost sphere of the lungs, whither also the atmosphere was transferred through the larynx (*e*). On the instant the blood also, which rushed from the venæ cavæ into the right auricle and cavern of the heart, began to be the proximate cause of the motions or pulses, even through the whole arterial system; the proximate cause having previously been the fibre and the spirit of the fibre (*f*). At the same time the organs of

proper essence of the body,—is the red blood, which is determined by the vessels. The mediate essence, on the other hand, is the animal spirit in the medullary fibres of the brain and the nervous fibres of the body. But the first or supreme and innermost essence of the body is the soul. See Part I., the Chapter on the Peritonæum, n. 313, 314. If then the causes of actions proceed inwards from the muscular fibres and the ribs, &c., towards the lungs, and never stop until they arrive in the innermost parts or in the vesicles of the lungs, of course the action proceeds from without to within,—*ab exteriori ad interiora*. Again, if the atmosphere be admitted to the innermost parts of the lungs, the same remark will apply; for the atmospheric air is the lowest aura of the world. For as we shewed in the Chapter on the Lungs, every action of respiration proceeds from the motion of the muscles of the thorax, in such a manner that not even the minutest particular of an action is impressed by those muscles, but has a similar action corresponding to it in the innermost parts of the lungs, consequently in the particulars of the respiration.

(*e*) All these points were shewn in the preceding pages, in treating of the trachea, the lungs, the pleura, and the diaphragm; and this change and inversion of the state of life, was also explained above, n. 429, *ad fin.*

(*f*) In so far as the heart is a muscle, and in so far as its arteries consist of a muscular coat, it is excited to its pulsations, or systolic and diastolic movements, either by the nervous fibre acting upon the fibres of the muscle, or by the blood. In the embryonic state, the

the five senses were opened, to take up on the first threshold the images, tones, forms, and all the play and manifestation of the circumambient world, and convey them inwards even to the soul (*g*). Thus we entered, or rather fell, from the highest life into the life of the body, which is the lowest, and the world's.

457. Now when the body undertook to manage the reins which the soul relinquished; when the machine was so completely inverted, that the powers flowed and rolled contrariwise, or upwards instead of downwards,—then, in order that the machine itself might not be prostrated and perish by its forces (*h*),

nervous fibre was the proximate cause, but after birth, the venous blood; as I think was proved in the *Economy of the Animal Kingdom*, in the Chapter on the Motion of the Adult Heart, n. 512 *seqq.*; and in the Chapter on the Arteries and Veins, n. 166—174. Thus the fibre which once was the active, motive and first cause, afterwards became the passive, reactive and remote cause. All the other structures that depend upon the heart and its vessels, appear to have undergone a similar fate.

(*g*) The same conditions are predicable of the sensoria, as of the motoria or the muscles of the body. The organs of the senses are the doors through which the varieties of the world flow in, and through which they penetrate to the intimate sphere, in short, to the soul. For instance the eye, which takes up the images represented by the mediation of the ether, and conveys them through the optic nerves all the way to the brain, and to the principles of the fibres thereof, and the most perfectly organic forms. Likewise the ear, which drinks the modulations of the atmosphere, and transmits them through the fibres of the seventh pair of nerves to the same destinations. In like manner the nares, which convey their smell through the mammillary processes; and the tongue, which conveys the taste in the same way through its sensorial fibres. Thus all things go from without to within; and so much is this the case, that our rational mind itself has to be educated, and we may almost say, to be instructed how to think and to judge, by its own ministering organs. See below, n. 458. Thus all things prove, that the animal machine is so formed, that the active forces tend inwards, until a kind of rational principle has sprung up, and has been so far educated by these influxes, that it can undertake the government, and hold the reins of its kingdom. But we shall treat of this subject in its proper place in the sequel.

(*h*) If we examine the animal machine with a proper amount of

and in order that the life that was now transferred to the body, might not be dissipated, and come to an end, it was provided and appointed that the lungs should perform a *mediatorial* office between the soul and the body; wherefore, to bring them into concord, the ordinances that follow were solemnly decreed. It was decreed,—I. That the alternate respirations of the lungs should concur, in momenta and degrees, with the alternate animations of the brains (*i*). II. That the will and nature should

insight, and consider it according to the laws of the doctrine of order and degrees, we shall readily see, that we live an inverted life, in fact, principally a corporeal or external life, and in no wise a spiritual or internal life; for all things that belong to the very life, have their beginnings from the body, and penetrate inwards. This is the reason why we are sometimes almost persuaded, that it is the body alone that lives; when yet all the life of the body flows forth entirely from the life of the soul; for we are deluded and led by the fallacies of the senses, for instance, to believe, that it is the eye that sees, and the ear that hears; although the eye and the ear are only the organs or instruments through which the soul perceives the modes of the ultimate world: thus the instrumental cause simulates identity with the principal cause. It is perfectly evident that these sensoria are only organs or instruments, from the very nerves that convey the modes of sensations to the brain; and it is equally clear that these senses are changed exactly in correspondence to the changes of state in those nerves, and in the brain. The same may be said of the life of the whole body, which life is purely sensitive, for actions are the determinations of this life, which are alive in proportion as they have sensitive life in them. But we must not delay longer at present over these considerations. Since the state of the life is determined so completely in contrariety to the order of the prior and former nature, hence, unless this had been foreseen, and provision made to meet it, the organic fabrics, in the revolution, might easily have been hurried astray, and have come to ruin; like machines acting against their wheels, or rivers against their sources. But these dangers are met from the very beginning, and this, by the mediation of the lungs.

(*i*) This, I think, I have satisfactorily proved in the *Economy of the Animal Kingdom*, in a particular Treatise upon the Coincidence of Motion between the Brain and the Lungs; and I have given further corroborations of it in the present Work, in the Chapters on the Lungs and the Pleura, &c. In the former chapter the following words occur:

flow into every act of the respiration; and that the former should conduct the inspirations, the latter, the expirations (*k*); wherefore the cerebrum was appointed to preside over the will, and the cerebellum over nature; and each had its own nerves allotted to it, to administer its department (*l*). III. That the

"The respiration of the lungs flows not only into the trunk of the body, but also into the head, and into its organs of motion and sensation; and in fact to the cerebrum, the very fountain of its motion, to which it rises in infinite streams, as it were in meanders and circles, and associates itself with the reciprocal respirations, or, as we term them, the animations of the cerebrum. Thus the lungs, and the brains with the medulla oblongata and spinalis, are synchronous in their respective animations and spirations; and this, in order that causes may act harmonically, and conspire in operation, with effects; things prior with things posterior; and the spirit of the soul with the spirit of the body; and in order that there may be an influx and reflux of the one into the other" (n. 398). See also *ibid.*, notes (*y*) and (*z*). The reader will find these statements established more in detail, by proofs derived from the nexus of substances, consequently of efficient causes, in the Chapter on the Pleura, &c, n. 424.

(*k*) This was likewise proved, under the sanction of experience, in the Chapter on the Lungs, where the following words occur: "The contraction of the voluntary muscles, united with the action of the atmosphere, gives the air the power of inflating the lungs, and of overcoming nature; and the contractile action of the lungs, in conjunction with a similar action on the part of the levers of the thorax,—the will the meanwhile being in a state of repose,—gives nature the power of throwing out the encroaching Æolus; hence the province of the will is confined to admitting, and during good pleasure retaining, the aërial guest; but driving it out, is left to nature" (n. 394). See also *ibid.*, (*m*). "Nature shares the empire with the will, for the latter only constringes the nerves and reins of the body, and keeps them constricted and drawn up, so long as it pleases; but as soon as it relaxes its hold, then nature takes up the government, and performs the contrary operation; as when we draw a bow, and then releasing it, shoot off the arrow, in which case the first act belongs to the will, the second, to nature, for the loosened string bounds back spontaneously, and the arrow flies to its aim" (n. 400). See also *ibid.*, (*m*).

(*l*) Inasmuch then as two principles bear sway in the animal body, to wit, nature, that is, the soul, in which this nature dwells, and the will, we may conclude, that this nature flows in, under the auspices of

lungs, as provisional powers, and common auxiliaries, should flow into these nerves, by the forces of their breathing apparatus, that is, by living forces of constriction and expansion, and should carry on the spirit of the fibres of the cerebrum and cerebellum, until it arrived at effects, or at the goals of causes (*m*). IV. That the lungs should infuse the general animations and motions of the cerebellum, into the members and

the supreme mind, from first causes, through intermediate causes, into effects; and that the will determines nothing into act, except according to those things of which the rational mind has been informed by the senses of the body: wherefore also the rational mind produces nothing by its will, as the principle of its actions, but what it has first imbibed and laid hold of by the way of analysis, or of the senses. Thus, since two principles of action exist in one body, it is necessary that there should be two brains; one of them to be subject to the empire of nature; the other, to the empire of the will. Were there only one, then either nature alone would rule, in which case there would be no need of external organs for instruction, for the life under whose auspices nature acts is infinitely superior in wisdom to our inmost sensitive life; or else the will alone would rule, in which case all things would go to wreck, and perish in less than a moment. Therefore nerves proceed separately from these two brains, by which nerves operations are determined, and which dividedly administer the government of the kingdom.

(*m*) It was shewn above in the Chapter on the Lungs, that those organs, by their respirations, or alternate expansions and constrictions, influence the nerves themselves, particularly those of the cerebellum, namely, the great sympathetic nerves, and the par vagum; and as external, corporeal and general causes, excite them to action (n. 399); and this, principally by the mediation of the pleura and the diaphragm (n. 447, 448). For in order that the organic fabrics or the viscera may be roused to their respective modes of operating, it is not sufficient that their nerves be inspired by the brains, but it is also necessary that the lungs, as general auxiliaries, infuse the respiratory motion, which is brought to pass by an action upon the pleura, the diaphragm, the peritonæum, and their ligaments; as well as by an accordant action upon the nerves themselves. This is the reason why the viscera of the abdomen are not inaugurated into their offices until after the opening of the lungs. That the lungs exert a similar influence and operation upon the phrenic nerves, see n. 449, 450.

viscera of the whole body, by actions directed upon the nerves of the cerebellum, as well as upon the mediastinum, the pleura, and the diaphragm, and by the mediation of these parts (*n*). V. That the lungs should enter all actions commanded by the cerebrum, or the will, and the very forms of all actions, with an assistant determination. And moreover should inspire them with all the spirit and fire of the will; so that all things should be brought out in the last sphere, precisely as they are represented in the first (*o*). VI. That the lungs should live and act entirely under the control and in the service of the cerebrum; so much so, as to enunciate and manifest by the larynx, prefixed as a head to their pipes, what the cerebrum revolves, cogitates, and decides, or what it commands to be uttered (*p*). VII. That the lungs should in no respect disturb the modes, or systolic and diastolic movements, of their neighbor the heart, and its arteries, but simply procure for these parts, by influx into their nerves, the power of acting according to causes generated in the body, or by the blood (*q*). And that the heart on the

(*n*) On this subject see the Chapter on the Lungs, n. 395, 396. In that Chapter it was shewn, that "the lungs not only effuse their moving breath or breathing motion into the general connecting media of the body,—as the tunics, the muscles, and the septa,—and thence into the viscera enclosed thereby, as the stomach, the liver, the mesentery, the pancreas, the spleen, the kidneys, the bladder, the testicles, the vesiculæ seminales, the uterus, the ovaries, and the rest; but they also infuse it into the distinct particular congeries and simple forms of those viscera, that is to say, into their lobules, glands, and follicles, down to the very intimate recesses of each: and thus the lungs excite them, every one, in their general form as well as in all their parts, to operate in accordance to their nature and structure, inspiring force into potency, and thereby giving birth to natural effects or actions" &c. (n. 396). See also the Chapter on the Diaphragm, n. 450; and the chapters on the several viscera of the abdomen in Part I. of the Work.

(*o*) The reader will find these points also treated of in the Chapter on the Lungs, n. 399—402.

(*p*) This was clearly explained in the Chapter on the Lungs, n. 403.

(*q*) That the lungs extend their sphere of activity to the heart itself, and to all its arteries and veins, see n. 397, where the following

other hand, by the pulmonary artery as a common key, should unlock the lungs, and thus constantly place the universal corporeal machine under the power and auspices of their motions; and by its blood should give back to the lungs in like manner the power of acting according to their causes (*r*). VIII. That

passage occurs: "The lungs . . . foster in their embrace this ruler of the kingdom, press him to their breasts, and reciprocate the act of love; for they likewise enter his pericardium with their common coat, by means of the mediastinum and the diaphragm; and they enter the sinus of his left auricle, with all their blood, venous constitution, marrow and life: nay, they even surround his great arteries and veins, the aorta and the vena cava, with the pleura, with the diaphragm, and finally with the peritonæum; and more than this, they enswathe his bifurcations, I mean, the ischiadic, spermatic, and many other vessels, with a similar covering. Thus the lungs extend their action to these parts, as well as to their head, the heart; so that wherever the heart penetrates by means of the arteries,—whithersoever it carries the circulatory motion,—thither also it brings with it the spirit of the lungs. The heart, by means of the arteries, diffuses the blood, or the corporeal soul, in all directions, while the lungs affuse the spirit of this world, the ultimate and corporeal spirit. Hence the ultimate or corporeal life is the result of the union of these two principles, the preliminary scene of its drama being opened and commenced by the lungs at birth, when we make our first entrance upon the theatre of this world's life." That the lungs also, by their action upon the cardiac nerves, communicate to the heart the power of acting, and in no way trench upon it, or hinder it from performing its alternate motions, see above, n. 423, where the following condition was stated to be one of the terms of a covenant between the lungs and the heart: "That the lungs, during each alternate draught, do admit, and lend their asssistance to infuse, the living spirit of the cerebrum and cerebellum into every nerve and muscle of the heart, its auricles, arteries and veins; so that the heart may perpetually enjoy the power of performing its systole and diastole, of which if deprived, it, and its vascular apparatus, would fall and die." See also *ibid.*, note (*c*).

(*r*) This was laid down above in the Chapter on the Pleura, n. 423, in the following words: "On the other hand, that the heart do pour forth through the venous artery, all its own or the body's blood, for the lungs to conduct to those innermost places of comitia or meeting, for the purpose of renewing the terms of the covenant every time; so

the heart with its blood and pericardium, and the cerebrum with its spirit and dura mater, should meet together at the pulmonary vesicles, and thus in the innermost sphere of the lungs, in which as from its first causes their mediatorial office commences (*s*). These are the conditions and solemn ordinances by which the discords of the new life are brought into concord. But in spite of all, perpetual contentions prevail, which constantly rend and depopulate the ill-adjusted state; whence sickness, disease, old age, and the necessity of death (*t*).

that the lungs likewise may perpetually enjoy the power of maintaining their respiratory alternations, of which if deprived, they and their air-pipes would collapse and perish." See also *ibid.*, note (*d*). For unless the heart flowed with its blood into the lungs, the latter could not possibly be raised, or exercise their respiratory alternations; thus the one obtains the power of acting from the other; but besides this, the one does not in the slightest degree influence the other's modes of action. Hence it appears, that the pulmonary artery is the very key which opens the door to all the operations that result from the action of the lungs; for were it not for the influx of blood from the heart through this artery into the lungs, not only they, but all the rest of the machine that depends upon them as its wheel, would come to a stand-still.

(*s*) It was shewn above in the Chapter on the Lungs, that the heart flows in with its blood and pericardium all the way to the innermost parts of those organs. That the cerebrum also flows in thither with its dura mater, see the Chapter on the Nose, n. 345, 348, where a communication was shewn to exist between the two meninges, and even between the medullary part of the cerebrum, and the pituitary membrane of the nares, by the medium of the olfactory nerves; also a continuation of the pituitary membrane not only over the palate, but also into the larynx and trachea, and consequently into the bronchia, and their ultimate vesicles. From this continuity and meeting it follows, that the heart and the brain are concentred, by means of their external coats, in the innermost parts of the lungs, and that thus they both acknowledge the lungs as mediators between the operations of both, according to the proposition of the paragraph.

(*t*) If we attend to the causes that are perpetually throwing our blood and animal spirit into turmoils and changes of state, it will be sufficiently evident, that the causes of the diseases, old age, and death, of the subjects of the animal kingdom, are derived from the above

458. Since, therefore, we are inaugurated into this life, that tends backwards from the last stages of the course to the first, the consequence is, that we are born in the densest obscurity, ignorant of all things, and the merest of infants; for the forces of the body, which are now the first causes, feeling nothing of themselves (*u*). Thus we live but little, if at all, in early infancy, for to feel is to live: yet this very life increases, grows, and approximates to perfection, as age advances. For the sensoria of the body are opened, into which the visible world flows, at first generally, indistinctly, and obscurely, with its modes and images (*x*). These modes creep up to the sensoria of the

source; I mean, from our inverted state of life, and the continual collisions and combats arising therefrom. It will be shewn, as I hope very clearly, in another place, that these are the intimate causes of all diseases, consequently of old age and death.

(*u*) It is a certain truth, that matter and body cannot feel, still less feel preëminently, or understand and think: this is repugnant to their nature. Considering then that life has been transferred as it were to the ultimate surface of the body, and more than this, that all passage has been precluded from the outermost to the interior sensoria, it follows, that the communication having been taken away, we possess very little life in early infancy; for the brain is appointed to preside over the external sensoria, and the way to the brain is not yet laid down or made ready. Moreover, it seems to be contrary to the laws of the order established by the Supreme Divinity, that this ultimate, obscure and indistinct life, should immediately commix, or should be confounded, with the life that is intimate, clear, and most distinct: wherefore not only does a wide interval forbid, but barriers also are interposed. Nay, even in adult age, these lives seem to be so perfectly separate, that while the one is acting, the other must cease to act; for while we are thinking intently, the external senses are spontaneously blunted, or deprived of their acumen.

(*x*) In the first instance objects flow into the senses in the most general manner; in fact, the universe is represented as one indistinct thing: afterwards, less general objects, and in process of time particulars, insinuate themselves. Thus the last compounds strike the senses first, and afterwards the different things that enter into the compound, until at last we perceive its parts distinctly. It has been frequently observed before in our analytical disquisitions, for instance, in speaking of the liver and the heart, that throughout universal nature,

cerebrum, which have been rendered accessible by conducting fibres, and produce changes of state therein, by which they teach [them] to receive, retain (*y*), and at last to perceive, that which comes up and penetrates through the external organic doors. Then, in process of time, sensual images, adopted internally in the sensorium of the cerebrum, become ideas; at first analogous to sensual [ideas]; afterwards, disposed into forms and series, they become proximately higher, or imaginative ideas; these at length put on rational forms, and become intellectual ideas (*z*). Thus we are instructed by the world, by means of the senses,

essences are at first thrown together as it were in a rude chaos, and there confounded with each other, but that presently, by means of divers organs applied for the purpose, they are divided and counted out into parts, and down to their unities, and so those things are brought out or evolved, that will contribute to the object in view, or to the effect of the end.

(*y*) It will be shewn in our Psychology, that the sensual images or modes that come up through the external sensoria, produce changes of state in the internal sensoria, and that these changes, which correspond to ideas, are themselves the ideas that are said to be imprinted upon the memory. But to state here, in advance, the place and manner in which these changes are effected, without having previously treated of the brain and its organism, would, I think, be premature. Meanwhile the following process is known to us all; that sensual modes are first simply received, and fixed in the memory, and that by the combination of them in various forms, a species of imagination is called forth, which increases for the most part as the memory becomes stored.

(*z*) We may all ascertain by reflecting upon our own minds, that the ideas which constitute the imagination, arise from a number of ideas analogous to visual [images]; and that the ideas which enter [into the form of] thought, and are termed rational and intellectual, arise again from numbers of these imaginative ideas disposed in analytic forms: thus the higher ideas are generated by a continual formation and as it were multiplication of the lower ideas. But such elevation to a higher power cannot possibly be accomplished, without a certain higher or spiritual power, which as it were presents itself and flows in; for that higher principle that rules the thoughts, and disposes the ideas of thought in analytic forms, cannot possibly be natural, but is spiritual, or is the veriest life of the thoughts.

the ministers of the life of the body, and are led from the darkness of ignorance more or less into the light of knowledge. There is in the cerebrum an eminent sensorium, and intimate recesses therein, whither these sensual rays of the body ascend, and where they can mount no further (*a*); there the soul resides, clad in the noblest garment of organization (*b*), and sits to meet the ideas emerging thither, and receives them as guests. This high and noble place is the innermost sensorium, and it is the boundary at which the ascent of the life of the body ceases, and the boundary from which that of the soul, considered as a spiritual essence, begins. Here especially, the soul infuses her power, and communicates the faculty whereby images become ideas, may be convoluted and distributed into rational forms or analyses, and may put on a certain spiritual attire (*c*); that is to say, whereby we are empowered to think below and above ourselves from objects of the understanding, to conclude from thoughts, to judge from conclusions, to choose from judgments, and thus to will and determine. Besides giving power and

(*a*) This eminent organism will be treated of in the Parts on the Cerebrum, and the Cortical and Medullary Substances thereof: for sensual images and modes, flowing along the continuous fibres, cannot stop excepting in the last and first boundaries of the fibres.

(*b*) If the soul be the principle of active life in the body, and if it flows in through first and through mediate causes, into ultimate causes or effects, then the doctrine, that the causes by means of which the soul prepares the ways for itself, are formed organically, is clearly a derivation from the fountain of pure philosophy; for whatever is the cause of the principle, is its instrumental cause. Wherefore this first cause is said to be organic in the most eminent degree, or as an organism infinitely to excel the inferior organic forms in perfection.

(*c*) Ideas themselves, intrinsically considered, are material, for they only flow in from the body by way of the senses; but when disposed in analytic order, they are no longer to be reckoned material, but rational. The task of disposing them thus can only be sustained by life itself; wherefore to live is to feel, eminently to live is to think and to judge. The soul itself, as we have often pointed out in our Analyses, only regards ends, and in effects, uses, which are its ends; wherefore we live more perfectly, the more we respect ends, and more sublimely, the higher the ends.

faculty, the soul gives us to distinguish, and as it were intimately to feel, whether the forms of images, and in fine whether the forms of ideas, are in agreement or dissonance with the order in which she herself is; if the former, she receives them with somewhat of love; if the latter, with aversion (*d*). The

(*d*) It is sufficiently manifest from the very series of our propositions, that there are no innate ideas in the human mind. The act of imparting the power whereby ideas may be distributed in analytic order, is as different from ideas, as the corporeal sphere from the spiritual, or as analysis from the ratios of which it is formed. Collecting and supplying materials, is one thing; building them into a house, is quite another. See above, n. 423, notes (*c*) and (*e*). The intimate faculty of feeling the goodness of forms, appears to be the only innate possession that we have; as was pointed out in the Prologue to Part I., in the following words: "The faculty of apprehending the goodness of all forms, consequently also the secret delights of truth, is inherent and as it were connate in our senses, both external and internal. The ear, although untutored, apprehends, and in some degree feels, the measures, the harmony, and the melody of tunes; for the mind is straightway affected in a corresponding manner: the eye spontaneously apprehends the beauties of nature, and the graceful and harmonic connexions between different objects: the tongue apprehends the agreeable qualities of viands and wines; and the nostrils, the fragrancies of various odors. So the rational mind, that is, the intellect, unhesitatingly distinguishes the truths of things, and the forms consonant to the order of nature,—at once to the nature of the universe, and to that of the intellect itself; for they sweetly sooth and please, and call forth deeply-hidden affections; wherefore, whenever a truth shines forth, the mind exults and rejoices:—a proof that a certain superior mind or soul, (which imparts to its mind, that is, to our rational faculty, a faculty inferior and subject to it, the power of perceiving, thinking, judging, and deciding,) at such times becomes kindlier, more free, as if liberated from chains, more active, more present in its influence, and closer in its correspondence. For the soul, which flows with its light into the sphere of the intellectual mind, has order and truth in it, and thus, by virtue of its very nature, it feels, approves, and indicates, in a certain universal manner, the presence of whatever is congruous or harmonic. What appears thus connate, is, however, an affection only, not a particular idea; since all particular ideas are learnt and formed by way of the senses and their organs" (n. 2).

intellect of the human mind is generated by the coöperation [of these two gifts of the soul].

459. Such appears to be the ground why what is termed the ANALYTIC way, or that which conducts us from the posterior to the prior sphere, or from effects to causes, that is, from the body to the soul, is the only way whereby the human race is permitted to attain knowledge and finally wisdom (*e*); and why the other, or the SYNTHETIC, which goes in the opposite direction to the analytic, is the way of superior beings, and, therefore, closed against, and even interdicted to, the inhabitants of the lowest world, or the dwellers upon the earth; for those who pursue it, rush into continual errors and fallacies, and at last into insanities, like men kicking against the pricks, and daring upon forbidden ground (*f*). Thus we can never arrive at the pinnacle of human knowledge and human wisdom, except by continual analyses and concatenated series, derived by induction, with the assistance of the sciences, from phenomena and effects; and even then, indeed, we can never mount to truths, whether natural or moral, still less to an understanding of spiritual truths, without the influx of a higher power (*g*). There are then three causes which lead us to intelligence; namely, ministering causes, mediate causes, and efficient causes. *Ex-*

(*e*) See the description of the analytic way or method, in the Prologue, Part I., n. 11.

(*f*) Respecting the manner in which the synthetic method carries the human mind altogether astray from the truth, and leads it into errors, and for the most part into insanities, which nevertheless appear to be rational, see Part I., n. 9, 10; from which it will be sufficient here to cite the following: "Hence errors, mental obscurity, fallacies, and strife; civil wars between the soul and the body; scholastic contentions about straws and trifles; the flight and exile of truths; and stupor and thick darkness in those very things where the light is most brilliant: and this to such an extent, that the very altars and their sacred fire are contaminated; which is the reason why the philosophy of the human mind is solemnly proscribed in the divine records. All these things flow from that single source,—we mean, from the habit and the propensity of reasoning synthetically" (n. 9).

(*g*) This subject is explained in detail in the following pages, in the series of the argument.

perience is the first or ministering cause; the sciences are the second or mediate cause; the faculty of thinking distinctly is the third or efficient cause.

460. With respect to the first division, or EXPERIENCE, it is this that supplies the objects of rational analyses, and the individual links of the chain, and as it were the materials for building the edifice (*h*). For nature and the visible world flow with these as their treasures, first into the organs of the senses, and through their open doors to the general sensorium, and at length present them for adaptation into analytic series as so many rational ideas and quantities. Each sense brings its gifts

(*h*) Experience is a word of very broad signification. It not only involves those things that have been discovered by the learned in the course of ages, committed to writing, and made part of learning,—as the experience of effects, or observations made upon the three kingdoms of nature, the mineral, the vegetable, and the animal,—hence metallurgy, botany, chemistry, anatomy, and in general all physical and natural learning; but it also involves those particulars that concern societies of men, their forms of government, customs and laws; as well as many other things that properly belong to experience, by virtue of which [experience] we are enabled to deduce and discover those things that are hidden in nature, or that are comparatively remote from our external senses. Among the materials of experience may also be reckoned those products that have been developed by the skill and ingenuity of the learned from the things just enumerated; for after they are once proclaimed, they become materials that, like the others, are fixed in the memory; and when registered among the sciences, they serve as bases for further investigation. But experience, in its most general sense, comprehends the whole collection of those things that have been examined by us, with the organs of the senses, from early infancy to adult age; in fact, that have been seen, heard, tasted, smelt, or touched; and that are fixed in our memories in the form of material ideas, and expressed by the formulas of words, of which speech is composed. For there are so many objects of the senses presented to every one from his early infancy. By means of these ideas, or these materials of primitive experience, we learn to comprehend and express the matters spoken of above; those, namely, that have been discovered by the learned world, and made part of learning. Thus whatever enters by the senses, and remains in the memory in the form of an idea, belongs to sensual experience.

and its treasures, and submits them to a kind of vision, not dissimilar to ocular vision (*i*), and thus carries them to the memory, into the little cells or receptacles thereof, from the gathered stores of which the rational mind chooses whatever suits its purposes, and takes it out and mingles it with its reasons. Hence, in proportion as the memory is enriched and provided with these materials, in the same proportion the rational mind, if backed by a happy genius, will be able skilfully, felicitously, and approximately and agreeably to the truth, to distribute its analyses into series, to adjust and conclude them, of many analytic conclusions again to form new analyses, and in the end to evolve its ultimate analyses (*k*). But to explore causes from effects by this way, ends from means, consequences from premises, or those things that are hidden from those that are apparent to the senses, is an arduous and vast undertaking. The experience of one man's five senses, although he should outlive the years of Nestor, is slender and poor indeed. We need accumulations of effects and phenomena, collected by numerous laborers in the field, and during successive lifetimes, and even centuries; for we must be instructed by all things of one thing,

(*i*) This may be best seen from articulate sounds; for each word or formula represents one idea similar to a visual idea; and as this calls forth other kindred and similar ideas, there arises a kind of internal sight, which is termed imagination; and again, when the ideas of the imagination are put together in a certain rational series, there arises an intimate sight, which constitutes thought: shewing that the objects of the external senses become converted in the first instance into visual images, before they are exalted into rational [images], and finally sublimated into the semblance of spiritual [images].

(*k*) This is corroborated by the common opinion, that the knowledge and intelligence of an individual are in proportion to the furniture of his memory. But it does not follow from this, that a powerful memory is always accompanied by ability, or by an understanding of equal grasp. For the faculty of reducing the contents of the memory to order, is a fresh intellectual requisite. An edifice is not built, simply by the accumulation of implements, bricks, tiles, and other materials; these are only confused preparations: art and skill must be tasked to put all things together in their places.

if we are to know that one thing thoroughly (*l*). Each contributes in some degree, and brings as it were its particular stone, to build this edifice that truths can inhabit. It is the province of the builder to fit everything into its proper place, so that all the materials shall be beautifully coherent, and harmonious in their tendency. Hence the learned world, and mediately the other branches of society, are furnished with the appliances and means of attaining knowledge and wisdom, in proportion as they are rich in the stores of experience. Of these stores memory is the treasurer.

461. With respect to the SCIENCES, or the methods and arts that constitute the mediate or mediant causes, they are the mistresses which teach us to reduce the accumulations of experience to order, to select what is fitting, to insert it in the becoming place, and as architects to construct the edifice, so that all things shall be put together according to rule (*m*). Then

(*l*) This was laid down more fully in our *Economy of the Animal Kingdom*, n. 12—17; where the following words occur: "Thus, in investigating the causes of the action of muscle, or the qualities of the moving fibre, unless we combine the particular experience of one individual with all the experience of others; and unless, in addition to this, we take into account the experience recorded of the blood, the arteries, the heart, the nerves, the nervous ganglia, the glands, the medulla spinalis, the medulla oblongata, the cerebellum, the cerebrum, and all the other members, organs, and tunics, endowed with the power of muscular motion: and furthermore, unless we avail ourselves of the facts that have been brought to light in physics and mechanics, respecting forces, elasticity, motion, and many other subjects,—unless we do all this, we shall assuredly be disappointed of the result for which we are striving" (*Ibid.*, n. 13).

(*m*) This is not the proper place to discuss the use of any science in particular, but only of science generally. The empirical sciences yield nothing more than materials and instruments, but the theoretical sciences give the laws and rules according to which we are to work. The latter are in a manner architectonic, and teach us to arrange the materials of experience in suitable order. There is, however, no science, either practical or theoretical, that must not have derived its elements from visible nature and the world: the sciences are only descriptions and as it were types thereof; for instance, those which teach the laws of motion, the rules of fluxions, or other harmonies and proportions,

again the sciences examine with their compasses and levels, and ascertain whether the building that has been constructed be graceful and regular in its result. It is utterly impossible by the help of experience alone, apart from the sciences, as patrons of genius, to climb to that Helicon where simple truths reside, and where causes take precedence of effects (*n*). For the sciences bring vague and scattered ideas together, under a few heads, and place them before the eye of the mind in a simpler and more connected form, and thereby give boundaries to the rational sight, and concentrate it more closely upon the essences of things: they also reduce those [ideas] to formulas or words, and circumscribe and define these words by terms, that they may fall the more easily and rapidly under the comprehension of the master and the scholar (*o*); thus they give a comparatively

are either deduced from nature itself immediately, or by the aid of conclusions from other sciences.

(*n*) Let us confine ourselves to the sphere in which we are at present engaged. From the mere anatomy of the animal body, we gather nothing more, than that the organic parts in any viscus have such and such a situation, consistence, and shape; but in order to bring out the use from the parts, and to carry on the chain until at length we arrive at the ultimate use, we must necessarily consult the sciences, and learn from them the nature of the case with respect to the connexions of things, and what they prove. Geometry, by its lines, as well as by its proportions and analogies, teaches what such connexion involves, and how one thing is related to another, and what series and equation results at last, when all are summed up analytically; from which result a conclusion may be formed respecting the ultimate effect and use. Philosophy on the other hand informs us, not merely that motions, forms, modes and qualities, are accidents, but also that substances are the subjects of all accidents; hence that motions, fluxions, forces, modes, effects and uses, are determined by means of substances; and since geometry has substances for its objects, and demonstrates their figures and forms, it follows that forces and all accidents whatever are similarly circumstanced; wherefore philosophy founded upon geometrical principles, affords us conclusive instruction respecting the effects of things. The same may be said in all other branches.

(*o*) As geometry in linear and figured objects; ontology in philosophical matters; and the rest of the sciences as well as arts, all of

clear representation of those things that result from the composition of a number of ideas into one, and in the end, from a number of such compound ideas, as conclusions; for these ideas are already products, and as it were children, conceived and brought forth by means of experience from the human faculties (*p*). But since in the nature of the world, and in the world of nature, and its three kingdoms, there are infinite varieties, hence infinite genera of these varieties, and species of these genera, therefore each genus is presided over by its tutelar muse, or its peculiar science, who keeps several other sciences under her general auspices, as a mistress having many handmaids; and each ancillary science of this genus has in like manner many others under her, as domestic servants; and these, in their turn, have their subordinates: for there is not the smallest part of a science, but is of such vast extent, that it has almost no bounds, and contains things so infinite, that it is sufficient of itself, as a particular science, to occupy the entire sphere of one under-

which have particular formulas and nomenclatures, by which their objects are expressed. For words involve the same number of ideas; for the most part, compound ideas; hence the same number of representations in the mind, which comprehend simultaneously in one series, whatever in common usage, is in them or is brought into them, by their definition. Thus a number of things are subjected simultaneously to the rational sight, and are instantly apprehended in proportion to the degree of our knowledge of the science to which they belong. Therefore all the ideas that are fixed in the memory, may be termed material; for although they may involve what is not material, yet in order to understand it, we are obliged to regard something relative or similar [to what is material], and thus to obtain for ourselves an idea by comparison.

(*p*) It is the province of the rational mind, to form one compound idea out of many ideas, and of many such compounds again to form another idea, and to advance in this manner by a continual progression, or successive elevation, to higher powers. But whatever is brought out and concluded by such means, is immediately registered among the ideas laid up in the memory; as for instance, the laws of motion, and many other things. Thus whatever is generated either by observation, or analytic induction, is retained under the form of an idea, without further rational investigation. Words themselves are but ideal types.

standing (*q*). But still there is a connexion of all the sciences, and finally a concentration into one, the universal of all (*r*), from which superior beings and powers contemplate and govern all lower things, as placed in the circumferences. To them it is given to descend by the path of synthesis, or from the prior to the posterior sphere, and through the veriest principles, and thus through the mysteries of our human sciences (*s*). Thus does the soul descend, under the auspices of the supreme mind, while it is constructing the body, and exciting it to act in conformity to its structure; and hence there is nothing, how deeply soever and intimately it be hidden in the bosom of our sciences, —in geometry, mechanics, physics, chemistry, optics, acoustics,

(*q*) This may be illustrated by the case of physics, mathematics, philosophy, metaphysics, and theology, which being universal sciences, comprehend in their embrace nearly all the other sciences: also by the specific sciences, which respectively to their particular subdivisions or branches, may again be considered as generic sciences. All the parts of each science, may themselves be elaborated and developed into so many new sciences; for there is nothing but what involves a kind of infinity: and this is the reason why no individual, in whatever department of a science or art he may be occupied, can ever attain to the complete perfection of it; but in the whole course of his life may still be advancing in some degree to that end.

(*r*) Respecting the science of sciences, or the universal mathematics, see the *Economy of the Animal Kingdom*, and specifically the Doctrine of Order and Degrees, or the Introduction to a Rational Psychology, n. 639, 649—651.

(*s*) The Prologue to Part I. contains the following statement upon this subject: "The power of divining true principles by the mind alone, and of descending therefrom, in the path of certainty, through their consequences, to posterior things, belongs exclusively to higher beings and powers; to spirits, angels, and the Omniscient Himself, who indeed inhabit the brightest light, and dwell in essential truth and wisdom. They see all things, in one complex, as at once beneath them and within them: they view the last things from the first, the lowest from the highest, the outermost from the innermost; in a word, all the circumferences from the centre; consequently, the very effects of the world, from their causes. Not so human minds, which derive from the senses, or absorb through the senses, all the materials which they have to reason upon," &c. (n. 10).

pneumatics, logic, psychology, &c.,—which the soul does not call forth in order, and determine into act, according to the end in view in the effect, or according to use (*t*).

462. THE FACULTY OF THINKING DISTINCTLY, or of taking a clear view of the ideas raised up to the ken of the rational mind, of combining them, framing them analytically, and lastly of bringing together the results of the reasons in one equation (*u*), in which [the mind] perspicuously contemplates the cause of its effect, and the progress of the means to the end,— this faculty is the efficient cause, and the highest natural gift. Experience and science, apart from this faculty, are administering and instrumental causes without their principal; and like forces without living power, which forces are dead (*v*). This

(*t*) The reader will find this laid down in many parts of our Analyses; as in the Chapter on the Larynx, where it was observed, that "there is nothing in acoustics, music, or harmony, be it ever so internal and arcane; there is nothing in the vibrations and tremblings of any continuous body, nor in the modifications of any contiguous volume or atmosphere, be it ever so hidden and profound, but nature has here brought it forth from the innermost, gathered it into one, and conferred it upon these two organs [the larynx and the ear]" (n. 359). If we carefully examine, and strive to explore, the mysteries of optical science involved in the eye; the mechanism involved in the universal body; the chemistry in the fluids; the philosophy in the internal sensoria, and particularly in the operations of the mind, we shall assuredly be forced to confess again, that mere wonders greet us, so that could we but really explore one ten thousandth part of them, "we should surely be stricken with holy amazement, and from that ground alone adore the wisdom of the Creator; and the pride of our knowledge and wisdom would not merely subside, but would fall prostrate in self-derision. Yet these are the lowest proofs of His omnipotence, for He has filled the vilest insect with similar miracles" (n. 455).

(*u*) The operations of the rational mind may not unfitly be compared with the analytical operations of the algebraic calculus; for in the algebraic equation, a number of ratios, and analogies of ratios, are collected together as in one sum, and the unknown quantities are discovered and shewn by the application of the known: but this comparison, God willing, will be stated more fully in another place.

(*v*) As we remarked above, not only experiences, but also the sciences, are matters of the memory, which matters the imaginative

faculty arises either from primary conditions, or from secondary, that is, use and education, but the best form of it is that which results from both. It arises from *primary conditions* in those whose fortunate lot it is to have the organs that take up, convey, and ultimately imbibe ideas, conformed to the rule and standard of nature, gifted with a liberal sphere of action, and with a power of disentangling multitudinous particulars, and arranging all things according to the present state of objects: also, to have a happy memory, that will appropriate objects accurately, distinctly assign to each series its proper chambers (*x*), and supply therefrom in due order those particulars which the mind decrees, desires, or is enjoined, to fit in, either as antecedents to conclusions, or as means to an advancing end (*y*). But

faculty may indeed reduce to a certain order, yet not into any order different from that which is wont to affect the external senses and the inferior mind of the body. But the act of abstracting corporeal and sensual ideas from them, or of so arranging those ideas, that they shall involve something comparatively remote from the senses,—this is the province of thought, consequently of the rational mind. Wherefore, without such a faculty as has the power of folding and unfolding reasons, until a certain analytic rationale or principle arises from them, which lies, not in the ideas themselves, but in their very nexus, and in the depths of their form,—we cannot advance a hair-breadth. This is the true living principle that infuses a kind of soul into the dead things or ideas of the memory. Each rational object has in a certain sense its own soul, which can only be communicated to it by that soul which is alive.

(*x*) We all know that some persons are born with almost superhuman memory; others with great activity of the memory, that is, with great imaginative power, and others again with other gifts, either of the body, or of the animal mind. Thus some are born poets; some, musicians; some, architects; some, mechanics. The natural inclination communicated by the seed of parents propagates this endowment as an inheritance to their children. And there is not a subject existing but what is born with some peculiar faculty. It would seem that what parents have so thoroughly acquired by use and education, that it becomes a part of their nature, is implanted in their posterity, in the form of an inclination.

(*y*) That which determines our thoughts to establish conclusions, is either some principle, taken from ourselves, or derived from others;

without the *secondary conditions* of use and education, we do but stop on the threshold, and scarcely survey anything more than the courts of nature, and not her magnificent interior recesses; wherefore the experiences, with the abundance of which at this day the coffers of the learned are overflowing, and with them the learning and arts that have grown in elaboration and completeness from the earliest ages down to the present time (*z*), must be invited into the memory, which is the treasurer of such things, must be acquired for use, and laid up as pledges. To these requisites we must superadd cultivation, or an assiduous awakening of our faculties, and a constant exercise of the gift itself, until it becomes a part of our nature. Above all things we must aim by education to become thoroughly imbued with the power of recalling the rational mind from the senses and the animal mind; in short, from cares, from the lusts of the body, the allurements of the world, and thus as it were from our lower selves,—while we are dwelling in its higher sphere; and this, in order that the sensoria of the body may be deprived of their light, so long as the sensorium nearest to the soul is lightened and illuminated with its light (*a*). By these means

this sometimes governs the entire train of thoughts, and we look in all directions for assurances or proofs of its correctness; wherefore the mind is said to *decree* it. The second case is, when any of us propose to ourselves an end, in which the mind contemplates a promise of future pleasure: the means to this contemplated end are what the mind is said to *desire;* for we embrace the means with the same love as the end itself, since we see the end as it were present in the means; and what is successive is represented as simultaneous. Thirdly, when neither the principle nor the end is put in the first place, but those things which the mind embraces as consequences of a chain of thoughts, —in this case the mind is said to be *enjoined* to embrace and acknowledge these consequences.

(*z*) See the *Economy of the Animal Kingdom,* Part I., n. 23, 24, 25.

(*a*) Daily experience shews the same thing; namely, that in proportion as light is subtracted from the external senses, it is added to the internal: which clearly proves, that somewhat of shade is drawn over the higher mind by the external senses, if they are taken into fellowship; and that rational analyses, by their very nature, separate

we mount to our higher mind, or to the soul, which then becomes accessible, and infuses power (*b*). For in proportion as we ascend upon these wings, in the same proportion that higher mind descends to meet us, and enfolds and embraces our wings in her winged sandals, and teaches us to convert our ideas into reasons, and reasons into analyses: for this is not a corporeal act, and therefore we cannot derive it from the senses, but from a power that flows into our sphere from the sphere above it. That this is no property of ours, but is made [to appear] as ours by a supernatural means of union,—of this we may be perfectly convinced by reflecting upon the operations of our rational minds: for from the mind as their fountain, we derive our sciences and arts; from the mind we take the laws and axioms, of which, when digested in becoming order, we build our doctrines, particularly our philosophical doctrines, which are the mere operations of the mind, explored by processes of intuition and reflection upon its modes of acting. Thus the principle that acts dwells altogether above us; and below [it], the principle that becomes conscious, and that is in some slight degree instructed respecting the manner in which the action takes place (*c*). But these are mere drops that we drink from this

and distinguish themselves. So long as we keep the rational mind in a merely reactive state, we are in the closest communion with the animal mind; but as soon as we bring it into a state of activity, we proportionably detract from the activity of the external senses. But we shall speak further of this subject in our Psychological Treatises.

(*b*) See what we said above on this subject, n. 458 (*b*) and (*c*).

(*c*) It is beyond all doubt, that the rational mind is in its very nature philosophical, and possesses the ability to arrange and distribute ideas in an analytic form, and to revolve and sum them up, so as to form a certain conclusion. For all our philosophy and logic is derived from no other fountain, or collected from no other streams, than from the operations of the rational mind, which not only herald with their light, but even instruct us, their subjects, in the matter of philosophy, and the manner of philosophizing; which shews that we cherish and possess in ourselves the very master of philosophy, to whose utterances the most learned among us must listen in humble dependence: and so much is this the case, that the philosopher may derive innumerable materials deserving to be inserted in his code, from the common herd

immense lake of knowledge and wisdom, and that we communicate to our lower powers by literary exercitations.

463. But although we may be surpassingly rich in experience, and accomplished in the sciences, and gifted besides with a faculty of thinking with the greatest distinctness, yet it by no means follows, that we shall therefore be able to rid ourselves of the mists that are involved in the fallacies of the senses, and in the fallacies, of sensual origin, of the rational ideas, and to enjoy an insight into real truths, in simple clothing, or naked loveliness. Those are only counterfeits and appearances of truth that the inferior faculties of the body present to the superior faculty. For certain misleading and as it were phosphoric fires, form an alliance of companionship with corporeal ideas, and mimic the real lights of life. These fires belong to the body, to the animal mind, and even to the rational mind itself. The fires *of the body* are the pleasures of the bodily senses. The fires *of the animal mind* are lusts or cupidities, whose name is legion. The fires *of the rational mind* are the ambitions and desires of ends, that converge to, and terminate in, the love of self, as the ultimate centre (*d*). These heats are

of the unlearned. The boy and the youth, in their simple speech, sometimes run through more axioms of philosophy and logic, through more categories, and series of consequences, than the prince of philosophers can distinctly set forth in his pages. Each copula or connexion of words, contains some philosophical principle; much more an entire oration; as every one may perceive, if he will only bestow a little attention upon particular cases. The mind does not derive these predicates from its body, but from a higher essence, in which the above faculty is innate; in fact, from the soul, which lives immediately under the auspices of the superior mind. Philosophy is a kind of anatomy of the human mind; for as we are ignorant of what lies hidden in the body, and of how the organic fabrics act upon each other, until the viscera are opened and examined, so also, without investigation, we are ignorant of what lies hidden in the mind. The grand philosopher is he, who scrutinizes these subjects with the greatest depth and distinctness.

(*d*) The particular nature of the affections of the body, and of the animal and rational minds, will be explained in our Psychology. Thus the affections of the senses of the body, are not themselves sen-

powers deriving their ground of activity from the body (*e*), which operating in the rational mind, extinguish that holy fire and

sations, but arise from the agreement or disagreement,—the fitness or unfitness,—of the forms that modifications constitute by their mutual relation or interaction. The affections of the animal mind result in like manner from the harmonies and discords of imaginations. The affections of the rational mind are the goods [bonitates] that are involved in truths, and respected in the ends which we propose and desire. If these goods result entirely from selfish loves, they are then like covered fires, which enkindle the sphere of the mind, and at the same time apparently illuminate it; so that there is always something either in, or under, its rational ideas, which caresses the selfish love. Hence minds in this state cannot possibly be affected by the pleasantness of truths, for they reject and abhor everything that does not primarily involve self: although this is not only directly contrary to the laws of truth; but contrary to the accomplishment of the very end for which we were created. For each individual is only a small part of society, nor does he exist for himself, still less does society exist for him, but that alone is his which results to him from his usefulness in the service of the public. Consequently, if he place the end in himself, he opposes a barrier which prevents the possibility of his aspiring to a more universal end,—to an end higher than himself.

(*e*) This is very evident from all the affections of both the animal and rational minds, which either exalt and vivify, or extinguish and kill the bodily life. Pride itself, when favoring breezes waft us on, or fortune smiles, not only puffs us up, but the vital spirits themselves become so hot, that we come into more close communion with the animal mind, into a clearer state of the understanding, and a greater fullness of life: yet it is only a heat, more or less internal or external, subtile or gross, according to the nature of that affection. All the affections, indeed, both of our rational mind, and of the animal mind, are given to us to serve as the fuel and heat of bodily life; but if we allow them unrestricted play, they burst into flames, and devastate the whole kingdom. But the pure heat that kindles the life of the soul, is so distinct from this heat, that the two cannot be present at the same time in one mind as their subject; wherefore the one is extinguished when the other is kindled. For this reason it is, that we are commanded to restrain the passions of the animal mind, and to extinguish the desires of the body, in order that we may allow the Divine Spirit to approach us.

purely spiritual altar flame. A light still remains, warm in relation to the body, but cold in relation to the soul and the superior mind (*f*). In this case, although we revolve and combine ideas with distinctness, and perspicuously contemplate analyses framed of reasons, yet these are only the spectres and impure phantoms of truths, which see ultimate ends in ourselves, and in the love of self, and which powerfully and confidently persuade us that they are Delphian virgins and graces; and lead us to think, that if we ourselves applaud them, the whole Parnassian band will applaud them as well: but they are far indeed from being truths, for they differ from them as much as the phantasms of the body and the mockeries of the world from the essences and forms of heaven. Thus if we wish to invite real truths, whether natural, or moral, or spiritual, (for they all make common cause by means of correspondence and representation (*g*),) into the sphere of our rational minds, it is necessary

(*f*) It will be shewn in the Doctrine of Representations, that rational sight is represented in ocular sight, and likewise [rational] light and the heat thereof [in natural light and heat]; and hence that we may arrive by means of comparison at some knowledge of those things that are above the sphere of our mind: for without the ideas insinuated and coming up through the external senses, we cannot possibly conceive those things that are above ideas: in fact, these must be in a manner attached to some sensual idea, before they can come to the sight of the understanding. It is from the ground of representative correspondency, that objects are presented to the eyes as clearly in the middle of winter, as in the middle of summer; so also to the rational sight; but the difference lies in the heat: also that we perceive the visible forms of objects by lamp-light, as well as by the light of the sun; yet every one knows what a difference there is between the two cases. This is the reason why light and clarity, as well as heat, and other things of the kind, are as it were appropriated to the intellect, as well as to the eye-sight.

(*g*) The reader will find this explained in our Doctrine of Correspondencies and Representations. I am not now speaking of geometrical and philosophical truths, which are indeterminate, and not applied to any natural or moral truth; but of the truths that result from the determination and application of these, to given objects, and thus redound to particular or general use.• For an infinity of truths of this kind have been discovered, and are in our possession; but when we

that we extinguish the impure fires of the body, and thereby our own delusive lights, and submit and allow our minds, unmolested by the influences of the body, to be illuminated with the rays of the spiritual power: then for the first time truths flow in; for they all emanate from that power as their peculiar fountain. Nor when they are present are there wanting a multitude of signs by which they attest themselves; namely, the varied forms of sweetness and delight attendant upon truth attained, and affecting the mind, as the enjoyments that result from the harmonies of external objects affect the lower and sensitive faculties of the body; for as soon as ever a truth shines forth, such a mind exults and rejoices (*h*); and this joy is the ground of its first assent, and of its first delighted smile: but the actual confirmation of the truth proceeds from its accordance with numerous reasons confirmed by experience by means of the sciences, and each point of which accordance receives a similar assent; the mind going onwards the while, with assiduous attention and pains, by the analytic way, or from effects to causes. In addition to these delights, there are still more universal signs; as the desire and the passion for attaining truth; the love of the truth attained, not for the sake of our own ad-

use them as bases for reasonings, or patrons of our faculties, we then, by various and unfair applications, form conclusions from them which are at variance with the truth: as we observed in the Prologue to Part I., where the following words occur: "For whenever affirmative reasoning is applied to a preconception, an infinity of particulars, all voting the same way, fly to its assistance,—both the decrees of ratiocinative philosophy, and the phenomena of the world, laid hold of in the fallacious light of the senses. Indeed, there is nothing but may form a constituent part in different series of reasonings, if not directly, at least obliquely; as a single particle of salt may form an ingredient in an infinity of savors, and a single color in an infinity of pictures," &c. (n. 9). With respect to the sciences, see n. 23, where it is stated, that "the sciences are indeterminate, and of no profit or advantage, unless they be applied and made subservient to uses. What is a knowledge of numbers, ratios, figures, and forms, in arithmetic and geometry, apart from its benefits in civil life? What are the philosophical sciences, with their predicates, qualities, modes, and accidents, without they have reference to reality?"

(*h*) See Part I., n. 2.

vantage, but of the advantage of human society; and neither for the glory of ourselves or society, but of the Supreme Divinity alone (*i*). This is the only way to truths: other things, as means, which are infinite, God Omnipotent provides.

464. But for what end, it is asked, are the hinges of our life so completely inverted, that the last things should play the first part, or that the bodily senses should inaugurate the mind, their mistress, into the sciences? and why should we not see from the beginning, by thoroughly prepared and finished organs, with the utmost acuteness, the perfect truth in everything? Assuredly the Supreme Mind, under whose auspices we live, never puts the least cause in operation excepting for the sake of an end; the series of causes and effects involves a corresponding series of ends (*k*); ultimate uses themselves declare to us the end intended by the effect; the rest is hidden from our view. But since ends, as well as causes, describe progressively a certain entire revolution and circle, hence there are proximate ends, remote ends, and ultimate ends. It is evident from a rational view of effects, that the PROXIMATE ENDS [of this inversion] are, *Firstly*, That we may inhabit the earth, the ultimate region of the world, or the floor of heaven, from which

(*i*) See the *Economy of the Animal Kingdom*, Part I., n. 19, 25, 26.

(*k*) It has been shewn throughout in our Analyses, that there is a perpetual chain of uses, corresponding to the perpetual chain of causes and effects, and a corresponding chain of ends in the soul, brought into play in the construction of the organic animal kingdom. Of this we may be still more clearly convinced by the contemplation of the universe; for if we only consider the circumambient atmospheres, the mineral kingdom of the earth, then the vegetable kingdom, and finally the animal kingdom, we shall have sufficient reason to conclude, that one thing generates and sustains another in a continual series, and this, by a wonderful circle; as is also the case in all the subjects of each of these kingdoms. If it be evidence of wisdom on the part of man to do nothing without an end and use, assuredly it is evidence of a Being surpassing wise, to found such an orb of uses, and to govern it with equal providence and wisdom. But to attempt to measure this orb of uses, or the government of this Providence, especially in human society, by the erroneous circles of our minds,—this is as impious as it is futile.

we are designed to emerge; and so may be subjects that can make use of all the plenty and the wealth with which that world and its three kingdoms are furnished and adorned: and that we may be essences and powers, that can convert these great possibilities to our own and the general weal (*l*). Therefore are we introduced, in the body first, into this world as a theatre, and its curtains rise by degrees; and thus these ultimate effects, like scenic shows, strike and fascinate with delight, our senses first, then the animal mind, and at last even the rational mind; and are a profit and use to us, mingled with sweet entertainment (*m*). Such could not have been the case had we commenced our lives with knowledge and wisdom; we should then have looked upon these shows as theatrical illusions, or laughing-stocks of our high faculties; we should have contemplated them, not as infants, but as aged fathers, with no pleasure of the senses. *Secondly,* that we may institute a kind of terrestrial society, in which these delights may increase by the communication of man with man, and in which the uses of things may be augmented by the aid of numbers, and those proper to the

(*l*) Apart from the subjects of the animal kingdom, nothing that the terraqueous world produces, could be said to minister a use. There must be subjects, in order that things may be applicable in the way of use: and furthermore, these subjects must have power given to them, to extend these uses still further, to multiply them, and to send them forth as it were in a new circle. For where there are causes, there also there are means, by which the effect is produced, and the cause extended. And inasmuch as nothing is done excepting for the sake of a use, it follows necessarily, that the subjects of the animal kingdom are means, which apply these uses to themselves, and carry on the chain of uses further; and indeed, at length so far, that effects, or last uses themselves, return by an incomprehensible gyre to their first end. Such is the progression of uses everywhere in the animal body.

(*m*) This is the reason why all things smile and seem full of joy in early life or childhood; and why they assume a comparatively gloomy aspect as old age comes on. For pleasure and delight are necessary, since without them, ideas are not insinuated into our minds, nor consequently do the organs open, and make the innermost sensorium accessible. These requisite conditions could not possibly exist, unless we led this inverse order of life.

individual may go forth by determinate channels to the community. Then a still more extensive field of uses is opened, into which we are led as members of society; and which consists in living for the human race by the mutual interchange of works of duty. This is the moral field, world, or estate, into which we cannot rise unless we have passed through the former, or through our corporeal and natural estate; this supplies the means to the moral estate as the end immediately above it (*n*): what results to the community from the administration of the means, is so far moral, as the intelligence and the will to which we attain, conspire to it. In order to the actual establishment of such a society, it is necessary that a diversity of manners should prevail, consequently a diversity of inclinations, affections, desires, ends, and principles; which could not possibly be brought to pass without an inverted state of life (*o*). *Thirdly,*

(*n*) In this, as well as in our ideas themselves, we contemplate an elevation, (in the present case, of uses,) as it were to higher powers. For the existence of the moral sphere, supposes the simultaneous existence of the natural and the spiritual, consequently the existence of the rational. The means are natural that we bestow or distribute, and are to be called duties, and reckoned among the virtues; but unless there be an end in addition, for the sake of which we dispense these means, in one way in preference to another, no moral result can accrue from them. Thus if we respect the advantage of society as the end, then natural uses assume a higher form. Wherefore morality is judged from the end, and is identical with virtue. But we shall speak further of this subject in another place.

(*o*) No society can exist among absolute peers or equals. The founding of a society involves a perpetual diversity of members. Such diversity can only be produced by this order of our life. It could not have place if we saw truths immediately by virtue of innate wisdom, for then there could be no diversity of principles, nor consequently of desires and affections: and as a further result, there could be no diversity of countenances and actions; and little or no speech; for the grand business of conversation consists in discussing what is true and good, and what false and evil; we approximate to one side or the other by probable arguments. If all things were seen with the most perfect clearness, as settled truths, there would be no occasion for reasoning, examination, and other processes, that occupy the minds and conversations of men.

that in this ultimate circle of nature, we may receive the wonders of the world, and as we ascend the steps and ladders of intelligence, receive still greater wonders, in all their significance, and with full vision; and that at length we may comprehend by faith those profound miracles that cannot be comprehended by the intellect: and from all these things, in the deep hush of awe and amazement, venerate and adore the omnipotence and providence of the Supreme Creator; and thus, in the contemplation of Him, regard as vanity everything that we leave behind us.

465. The REMOTE or prior ENDS of the inversion of the order of life (*p*), are, that the last sphere may be united through man with the first, the lowest with the highest, the worldly with the heavenly, or the corporeal with the spiritual; for these in themselves, and in their nature, are so dissimilar, and so widely separated, that they cannot possibly come together without some uniting medium. Our rational mind is that uniting medium, where mystic meetings are carried on, and sacred covenants ratified. This enables us to be and to live, for that which is our mind's property, is peculiarly our own; all things that belong to the body, belong to the mind; by virtue of the mind we are entitled to the name of men; how much soever of it, and whatsoever of it, is involved in our actions, is regarded as human; from it we derive the knowledge of things below and around us; and from it, by relation, we are rendered conscious of ourselves; and by faith, embrace those things that are above us. Now since worldly things flow into it from the lowest sphere, through the gates of the senses, and heavenly things, from the highest, through the portal of the soul, hence it is the true centre of the universe, divided into two powers; of which one, namely, the corporeal, is the very thing that is properly our own; to this is given a will, and to the will, liberty, in order that it may be our own choice to live to the body, or not

(*p*) The proximate ends, or the causes thereof, respect the corporeal state with which our lives commence. Hence the ends, or the causes, that follow, and ascend to the prior or still higher ends, are termed remote; and are intermediate between the lower and the higher.

to live to the spirit (*q*). But the other power, or the spiritual, is not of our power, because it is above ours; hence it is not for the forces of the body, or for the will thereof, to be united to the superior power, but it is for the superior to be united to the inferior which is ours: thus union is possible on the part of the spirit, but not on the part of the body (*r*). The ideas of our intelligence are so many dead forces; the ground from which they can live must be infused into them from above. But by the Supreme Mind means have been most mercifully provided, whereby the superior power is enabled to adopt the inferior, in order that both may be united in a sacred bond (*s*). In consequence of this, we are organic subjects (*t*), through which the lowest things ascend, and the highest descend; and human

(*q*) We shall treat of the will and liberty, God willing, in our Psychology; wherefore we only touch upon them slightly in this place; just so much, in fact, as to be able to shew from them, that for many, and even for these ends, we live at first almost in the body alone, and ascend to a higher life by degrees. Otherwise the will would not be thus free on the part of the body.

(*r*) That which is relatively imperfect, cannot unite itself to that which is more perfect; nor the lower to the higher; nor consequently, the body to the soul: but the soul must unite itself to the body, and reduce its body to such a state, that it can serve the soul as an organ. To induce order upon things that are below, so as to bring them into harmony, is the exclusive province of the higher power; and this is the reason why we cannot investigate truths without an influx from above. Hence it is evident how important it is, that we should have a distinct conception of the nature of the inferior and of the superior sphere, and of the posterior and the prior; for the prior and the superior is more perfect than the posterior and the inferior. On this account, the doctrine of order and degrees should be sedulously cultivated.

(*s*) I forbear to recount these means in this place, because they are sacred and theological subjects; and for the same reason, I pass over what is said to be done on the part of the body or the will, by the application thereof, the removal of impediments, and other processes.

(*t*) I must not at present expatiate upon the proofs of this proposition, for it would carry me out of my field. Meanwhile, we are none of us ignorant of the text, that "in God we live, and move, and have our being."

minds are the very receiving-rooms of both these guests; thus either temples or precincts of temples; consequently perpetual objects of Divine Grace and Justice.

466. The LAST END, which also is the first, is, that our minds, at length become forms of intelligence and innocence, may constitute a spiritual heaven, a kingdom of God, or a holy society, in which the end of creation may be regarded by God, and by which God may be regarded as the end of ends. From infinite wisdom, added to equal power, and this to equal providence, such perpetual end flows constantly, from the first end to the last, and from the last to the first, through the intermediate ends, that declare the glory of the Divinity (*u*).

(*u*) I shall treat of these subjects, by the blessing of God, in the last of my analytic parts. But as yet we are dwelling in the mere effects of the world, which exhibit the amazing and divine circle of these ends before the contemplation of our very senses.

END OF PART II.

THE

ANIMAL KINGDOM,

CONSIDERED

ANATOMICALLY, PHYSICALLY, AND PHILOSOPHICALLY.

PART III.

THE SKIN, THE SENSES OF TOUCH AND TASTE, AND
ORGANIC FORMS GENERALLY.

THE ANIMAL KINGDOM.

PART III.

PROLOGUE.

467. In the two preceding Parts we treated of the viscera of the abdomen and thorax, or of the organs of the inferior regions of the body; in the present Part we shall commence to speak of the supreme region, or of the head, and its organs, the external sensoria,—the sensoria, namely, of touch, taste, smell, hearing, and sight: for it is our intention to advance and mount in regular order, strictly according to the analytic way, from the posterior to the prior sphere, rising successively from the lowest forms, powers and forces of the human body, to the higher and the highest; and thus, with doctrines to guide us, to search out the essences and natures of things by the indications and evidences of effects. To attain this end, it behoves us to observe the order that nature herself marks out, and as it were dictates to our intellect; in doing which, and following her, it will be found that she herself now opens to us the subject of the present Part. For the circumstance that one thing follows, unfolds, develops, consequently opens, another, originates from order alone. A rambling investigation, conducted without order, or what amounts to the same thing, without the contemplation of causes in a connected chain, may lead to the precipitate formation of surmises and conjectures respecting truths; which, however, are mutually bound to each other

in concatenated series, and only in that series allow themselves to be properly surveyed. The thing which takes its form from a random procedure, or loose and desultory investigation of this kind, constantly retains a similar, that is, conjectural character, in its successive developments, since it induces the same form upon the whole series of things that come after it. For whatever idea is assumed to start with, determines a corresponding principle of the thing, and this principle, a corresponding interpretation of the things flowing forth therefrom, or a corresponding intuition of the mind in those objects; therefore, a corresponding conclusion. Hence come hypotheses, which are closely analogous to the unnatural marks and excrescences contracted by the body of the embryo in consequence of the disordered impressions of the pregnant mother.

468. If we view things in a confused or superficial manner, through the coverings in which our senses envelop them, we may readily be induced to believe, that the supreme region of the body is constituted by the external sensoria of the head, as well as by the internal, of which the brain is the complex: but if we consider the grounds of things, and make use of greater diligence, distinctness, and depth of thought, we shall clearly see that there are three spheres in the living body, one superior, prior and interior to, and simpler than, another, each of which is divided into its regions; namely, a sphere of effects, a sphere of causes, and a sphere of principles. The SPHERE OF EFFECTS, which is the lowest or the outermost, properly involves that which is called the body, and comprehends the viscera of the abdomen and thorax, and the external sensoria of the head. The SPHERE OF CAUSES, which is the superior or middle sphere, properly includes that which is called the cerebrum or brain, this sphere being the proximately efficient cause of the effects and determinations in the body. On this account the cerebrum, in the wide acceptation of the term, is walled round by osseous boundaries of its own, and like the body is divided into regions, of which the cerebrum, properly so called, constitutes the first; the cerebellum, the second; the medulla oblongata in conjunction with the medulla spinalis, the third. But the SPHERE OF PRINCIPLES, or the supreme and innermost sphere, as it were the Olympus or heaven of the other spheres, is the

cortical or cineritious substance, from which, as their beginning, the fibres spring forth, and at which, as their end, they terminate: for the fibre born of this substance exercises all influence, and delineates all structure, in the universal body; from it the determinations of the will flow down into act, and to it the modes of sensations flow in until ultimately they reach the intellect; for the soul resides in this substance as in its principles. But we shall speak more fully of this partition of the animal kingdom into spheres, and of these spheres into regions, in our next Part, in treating of the Cerebrum.

169. In the Index of Contents of the whole Work, I promised that at this stage I should proceed to treat of the Heart, the Arteries, the Veins, and the Blood; of the Genital Members of Males; [of the Genital Members of Females], and of the Formation of the Fœtus in Utero. But the heart, the vessels, and the blood, have already been fully treated of in my *Economy of the Animal Kingdom.* And with respect to the members subservient to generation, they must come before us in the sequel, after we have discovered the nature of the animal spirit, and the nature of the soul; for by these organs the soul comes off from itself into the offspring, for the purpose of founding a new kingdom. I think it would therefore be premature, and that I should be unprepared, to declare anything definite of these members, as instrumental causes, without a previous knowledge of the principal cause. Our treatise would want the proper clearness and meaning, unless we had previously defined that of whose organs we were speaking,—those organs by means of which new forms are conceived in the image of the form preceding them. Wherefore, in order that the investigation may proceed with regularity, I have considered that we must first ascend by degrees to the supreme sphere, from whence we may legitimately deduce the principles of things, and where we may speak of the soul with comparative certainty and definiteness.

CHAPTER I.

THE SKIN AND THE SENSE OF TOUCH.

470. HEISTER. "The cuticle is a thin membrane, closely encompassing the whole skin, of which it is in a manner a part, and on this account also called by the Greek name, epidermis. It adheres firmly to the cutis by the intervention of the corpus reticulare Malpighii; insomuch that in the dead subject it cannot be separated by the scalpel, although it may be brought away by the action of boiling water. Sometimes, however, even in the living subject, we find it detached from the cutis by putrefaction, fire and blisters. The cuticle is white in the European, black in the Ethiopian or negro. Its structure or substance consists of extremely minute lamellæ, and as it were little scales, but which are closely connected to each other, and require the microscope to shew them. In these lamellæ there are a great multitude of little foramina, affording egress to the hairs, the transpiration and the sweat, and ingress to mercury and other things: these foramina are commonly called pores. Some anatomists regard them as having valves, for regulating the escape of the sweat, but I am inclined to think that this object is better ensured by the elasticity of these vessels. The thickness of the cuticle varies in different parts, being greatest in the soles of the feet and the palms of the hands: in other parts the cuticle is very thin. We see in it various furrows or lines, called by Pliny, incisuræ, which are deeper in some places than in others, and exist all over the surface, but particularly in the palms of the hands. The furrows in the latter situation are appealed to by fortune-tellers as prophetic indications. On the tips of the fingers the furrows are spiral, and seem to defend the excretory ducts of the cutis, which are there arranged in a regular order. The cuticle is easily reproduced in living subjects; although it does not originate, as old writers supposed, from the condensation of the exhalations of the body by the air; but rather,

according to Leeuwenhoek, from an expansion of the excretory ducts of the cutis; or according to Ruysch, from an expansion of the nervous papillæ of the cutis,—the papillæ forming a multitude of minute scales or lamellæ, all connected together; or perhaps, as it seems to me, from both these sources combined. . . . Even Ruysch, with his finest injections, was never able to discover vessels in the cuticle, nor has any anatomist since his time succeeded in demonstrating them. Admitting that none such exist, we can then account for the fact, that the cuticle does not bleed when cut, and that it is almost destitute of sensibility; although of course it must be nourished and reproduced by a subtle fluid of some kind. . . .

471. "The corpus reticulare Malpighii, or reticulum cutaneum [rete mucosum], is an exceedingly fine, delicate membrane, perforated like a net with innumerable minute foramina. It lies immediately under the cuticle, and when the latter is brought away from the cutis, either by artificial means or by accident, the reticulum adheres so very firmly to it, that a separation of the two becomes almost impossible, the reticulum seeming to be nothing more than the inner surface of the cuticle. In examining the reticulum, we find that it is most abundant in those places where the sensibility of the skin is most acute, as in the palms of the hands, the tips of the fingers, and the soles of the feet: it is also seen on the tongue, and indeed much more plainly and distinctly than elsewhere; and the tongue, therefore, is the part in which its nature and constitution may be most successfully investigated: in other parts it is so thin as to be scarcely discernible. It is of a white color in the European; but deep black (although the cutis is perfectly white) in the Ethiopian: in the mulatto [semi-Ethiopian] it is of a lighter shade. Hence the color of different races, and especially the blackness of the Ethiopian race, is mainly dependent upon this membrane. Its uses are, to transmit through its little foramina the hairs, the cutaneous papillæ, and the excretory and absorbent ducts of the cutis; to maintain these parts in a certain and determinate arrangement, so as to prevent them from being easily moved away from their places: and it also appears to preserve the softness of the papillæ, and their aptitude for touch.

472. "The cutis is a strong membrane, as thick as [ordinary] leather, of an elastic character, and investing the whole body. By its upper surface it is connected with the reticulum and the cuticle; by its lower surface, which is slightly pitted, with the fat; this latter connexion being loose in some parts, but very close in others. Its thickness and consistence vary in different parts of the body; and also in different animals, as we know by the differences in leather. It has a

number of furrows, incisures or lines, common to it with the cuticle. It exhibits certain large openings, as in the mouth, the nose, the ears, the anus, &c., in which parts, however, the cutis may more properly be said to be reflected than perforated: and also smaller openings, commonly called pores, which in their turn are subdivided into great and small, and give egress to the hairs, the transpiration, and the sweat; and ingress to mercury, the matter of contagions, &c. The larger pores are visible to the naked eye, in the nose and ears particularly; but the smaller pores are demonstrated by the microscope, and by the passage of mercury through leather. If we examine the structure or substance of the cutis, we shall find that it consists of a wonderful plaiting of very tough, single, tendinous fibres: of vast numbers of blood-vessels first properly brought to light by the stupendous injections of Ruysch: . . . of a multitude of nerves constituting papillæ, for the most part pyramidal in shape, and reaching forth through the Malpighian rete to the cuticle: these papillæ are most conspicuous (that is to say, after the removal of the cuticle) in the lips, the palms of the hands, especially about the tips of the fingers, and in the soles of the feet, and constitute the primary organ of touch. Most of the later anatomists, after Steno and Malpighi, assert that immense numbers of miliary cutaneous glands exist everywhere in the cutis, for the secretion of the matter to be perspired; but these can scarcely be demonstrated at all, much less in any number; and the function attributed to them may be performed without their aid, by the little arteries of the cutis. The cutaneous follicles or receptacles are perhaps identical with the sebaceous glands of some authors. . . . The hairs also are usually considered as belonging to the cutis, and are found in the greatest quantity on the head. When they grow on the body they are called pili; when on the head, capilli, &c." *(Comp. Anat.*, n. 196—199.)

473. Winslow. "The cutis is a tissue of very large extent, made up of several kinds of fibres, tendinous, membranous, nervous, and vascular, the interlacement of which is the more wonderful, in that it is very difficult to unfold, being in every respect as complicated as the texture of a hat. This tissue is what we commonly call leather, and constitutes the body of the skin. It is not easily torn, but yields in all directions, and afterwards recovers itself, as we see in fat persons, in pregnant women, and in cases of swelling: and it is thicker and more compact in some places than in others. Its thickness and consistence are not, however, always proportionable to each other; for on the back parts of the body it is ordinarily more thick and less compact than on the fore parts: and on the palms of the hands and soles of the feet, its thickness and compactness are nearly equal. . . . The

outer surface of this tissue terminates in small eminences, called by anatomists, mammillæ or papillæ, in which the capillary filaments of the cutaneous nerves end in the form of small radiated pencils. These papillæ differ very much in figure and arrangement in different parts of the body, so that they may be distinguished into several kinds. They are for the most part flat, of different breadths, and separated or cut off from each other by furrows or sulci, which form the parts between them into irregular lozenges. The pyramidal figure generally ascribed to them is not natural, and appears only when they are contracted by cold, by disease, by boiling, or by any other artificial mode of preparation which alters their ordinary conformation. The papillæ of the palm of the hand, of the sole of the foot, and of the fingers and toes, are higher than those of other parts, but smaller, closely united together, and placed as it were erect one against another, in particular rows, which represent on the skin all kinds of lines, straight, curved, waving, spiral, &c. . . . The red part of the lips is also made up of papillæ, resembling very fine hairs or villi closely united together. There is another peculiar kind under the nails; the papillæ there are more pointed, or in a manner conical, and turned obliquely toward the ends of the fingers. Those which are found in the hairy scalp, scrotum, &c., are again of other kinds.

474. "The papillæ of the first and second kinds appear to be surrounded at their bases by a soft, mucilaginous, but somewhat viscid substance, which fills the bottom of the interstices between them, and represents a kind of network or sieve, the meshes or holes of which surround each papilla. This substance is generally called the corpus reticulare or mucosum. Its origin has not hitherto been satisfactorily explained; and it has not been determined by demonstrative proofs, whether it separately forms a universal integument, or whether it belongs more properly to the body of the cutis, than to the papillæ and epidermis. . . . In inflammations we observe naturally a peculiar network of capillary vessels, more or less extended on the surface of the cutis; and minute anatomists clearly demonstrate the same thing by their fine injections, which may be looked upon as artificial inflammations: but neither inflammation nor injection proves, that in the natural state these capillaries are blood-vessels properly so called, that is to say, vessels which contain the red portion of the blood. It is more probable that this vascular texture is a continuation or production of the finest capillaries of the arteries and veins, which in the natural state only allow of the transmission of the serous or lymphatic part of the blood, while the red part continues its course through the wider ramifications, which more properly have the name of blood-vessels.

This vascular interlacement or network is of various forms and figures in different parts of the body: thus it is quite different upon the skin of the face, from what it is elsewhere, and it is even different in different parts of the face, as may be seen by the most ordinary microscopes. . . .

475. "The inner surface of the body of the cutis is covered over with granules or small tubercles, commonly called cutaneous or miliary glands. . . . These granules are partly imbedded in the substance of the cutis, in little fossulæ, which answer to the same number of little moulds or caps in the adipose substance. Their excretory ducts open on the surface of the skin, sometimes through the papillæ, sometimes on one side of them; as may be seen at the ends of the fingers, even without a miscroscope. The greater part of them are the sources of the sweat, and there are some of them that supply an unctuous and fatty matter, of different density, as in the hairy scalp, on the back, behind the ears, at the end of the nose, where in certain subjects this matter may easily be squeezed out in the form of small worms. . . . By macerating the skin in water, or any other convenient liquid, these granules or corpuscules become very visible, especially in the skin at the end of the nose, and in that of the arm-pits. The late M. Duvernay clearly demonstrated to the Royal Academy of Sciences, the structure of some of these cutaneous glands, which appeared like circumvolutions of small intestines, plentifully supplied with capillary vessels. The illustrious Morgagni, professor at Padua, has given the name of glandulæ sebaceæ to those which furnish the unctuous matter above mentioned. Besides these granules, there are other small, solid and hardish bodies, almost of an oval figure, contained in the substance of the skin. These are the roots or bulbs from which the hairs arise. . . .

476. "The skin is perforated by an infinity of small holes called pores, which are of two kinds. Some are more or less visible, as the orifices of the lacteal ducts of the mammæ; the orifices of the excretory canals of the cutaneous glands, and the passages for the hairs. The other pores are imperceptible to the naked eye, but visible enough through a microscope. Their existence is also proved by the cutaneous transpiration, and by the penetration of the subtle parts of topical applications; which two circumstances may furnish legitimate reason for dividing these pores into arterial and venous. . . .

477. "This entire apparatus of the skin is covered exteriorly by a very thin, transparent web, which is closely joined to it, and is called epidermis, cuticle or scarf-skin. The substance of the epidermis appears to be very uniform on the side next the cutis, and on the other

side to be made up of a great number of exceedingly fine squamous laminæ, without any appearance of a fibrous or vascular texture, except some filaments which connect it to the papillæ, and which, perhaps, are detached from thence. This substance is very solid and compact; yet capable of swelling and thickening, as we see by steeping it in water, and by the blisters raised on the skin by vesicatories, or any other means; and hence it would seem that it is of a spongy texture. It yields very much in swellings, but not so much as the cutis, without breaking or cracking. The origin of the epidermis is as obscure, as its reproduction is evident, sudden and surprising, in that it grows again, however often it is destroyed. Probably it arises from a substance that exudes from the papillæ, and if so, the ancients appear to have had reason with them when they called it an efflorescence of the cutis. We must not however imagine, that it is the air which dries this mucilaginous matter, and gives it the form of epidermis: for the epidermis is found equally formed in the fœtus, which swims continually in water; and it is reproduced on the palate, after having been brought away by too hot food; as well as under plasters applied to any part of the body. Hard and reiterated friction detaches it more or less imperceptibly, and presently afterwards a new portion or layer is produced, which lifts up the former layer, and this happens again and again. . . . The epidermis adheres very closely to the cutaneous papillæ; from which it may be separated by boiling water, or . . . by maceration for some time in cold water. . . . It adheres still more closely to the corpus reticulare, which is easily raised or detached along with it, so that the one seems to be a true portion or continuation of the other. . . . If we narrowly examine the little pores or holes through which the sweat passes, the epidermis will be seen to enter them, in order to complete the excretory tubes of the cutaneous glands. The fossulæ of the hairs are also furnished with similar elongations of epidermis; and even the hairs themselves appear to receive from it a species of bark. The almost imperceptible canals of the cutaneous pores are also lined with it internally. By long maceration of the skin in water, the epidermis, with all its elongations, may be detached from it; so that the latter carry with them the hairs, their roots or bulbs, and even the [cutaneous] axillary glands." *(Exp. Anat., Hist. gen. des Tegumens,* &c., n. 5—44.)

478. LEEUWENHOEK. "I pared the skin on the inside of the hand and fingers, where it was sufficiently thick . . . to enable me to cut off three or four lamellæ without drawing blood. At length, by repeated observations and experiments, I obtained such results, that I can state for certain, that in the whole field of the external skin of the

body there is no space but what is perforated with excretory vessels; through which vessels, in healthy subjects, both aqueous moisture and fat exhale in a perfectly orderly way. These vessels, which perforate the surface of the skin in vast numbers, and are covered over with a kind of little scale, are so large, that their diameter is three times that of their mouths or orifices. But when placed under the microscope, they are generally seen folded together, just as the blood-vessels in the flesh of animals are found to collapse when emptied of blood. Hence it is, that out of five and twenty such vessels, (however thin may be the lamellæ that are pared from the skin,) we can scarcely find a single one that seems pervious to the sight. . . . Several times I applied a clean piece of glass for a moment to the face, just under the eye and close to the nose, where the skin is comparatively seldom touched or wiped; and when I submitted the glass to the microscope, I found it much stained with fat. Afterwards, having cleaned the glass, I wiped this part of the face, and rubbed it well with a clean towel until the skin became red; and in order that no portion of the fat which was on the towel should be communicated to the face by the repeated rubbing, I frequently changed the part of the towel which I made use of. Then, in less than a quarter of a minute, I again applied the glass to the clean skin. And on again submitting the glass to the microscope, I saw so incredible a quantity of fatty and most minute halitus settled upon it, as scarcely any one can conceive without witnessing. After this, I repeatedly wiped the skin with a perfectly clean towel, and particularly that part of it to which I was about to apply the glass: and in less than a minute I applied the glass to the face. And when I looked at it as before, I again saw the fatty halitus, but separate from each other. . . . Inasmuch as the vessels covering the skin lie so close together, and the skin itself is roughened by various little excavations and eminences, therefore these vessels are not distributed in an orderly and regular series. . . . Their mouths or orifices . . . look partly upwards, and tend partly in an oblique direction. . . . I pared several lamellæ from my skin, and submitted them to the microscope, and saw with no small delight that a little piece of skin no bigger than might be covered by a common grain of sand was perforated with innumerable pores; which I distinguished with great clearness, the case being much as if we were to prick a little piece of paper with a very fine needle, and see the sun shining through the holes. . . . According to the best estimate I can make, I conclude that a piece of skin the tenth of an inch long contains at least a hundred and twenty vessels. But let us be content with the round number of a hundred. Then a piece not above an inch long must hold a thousand vessels; a piece

a foot long, twelve thousand vessels; and a square foot of skin, a hundred and forty-four millions. Hence if we reckon the surface of a middle-sized man to cover fourteen square feet, it will follow that his skin is perforated by two thousand and sixteen millions of vessels." (*Epistolæ Physiologicæ*, Epist. xliii., p. 405—413, and fig. 1, 2, 3, 4, 5; Delphis, 1719.)

479. BOERHAAVE. "The excretion of the sweat.—Underneath the cutis, upon the fat, all over the circumference of the body, lie what are called the miliary glands; thickly set; furnished with an artery, vein and nerve; and giving forth an excretory vessel, which rising through a foramen in the reticular substance, discharges the sweat by an open orifice under the epidermis; and is covered by a hollow, elevateable, roundish valve, placed beneath the cuticle, and capable both of transmitting and confining the humor. This [vessel] is the principal organ for the excretion of the gross sweat; there being other vessels, namely the vascula Ruyschiana, for pouring out the thinner moisture. (*Inst. Med.*, n. 424.) The Sanctorian [or insensible] perspiration.—Besides the above, there are other exhalant vessels under the little scales of the epidermis, opening obliquely, and of such exceeding fineness, that Leeuwenhoek reckons that 125,000 of them open in a space that may be covered by a single grain of sand. By these vessels a most subtle humor is constantly transpiring from every point of the body, which humor is named the Sanctorian perspiration, from its discoverer, Sanctorius, who has all the credit both of originating and completing this [branch of the] doctrine [of the skin]. The exhalation of this humor is carried on by the whole external epidermis, as well as by the cuticle of the mouth, the nares, the fauces, the larynx, the lungs, the œsophagus, the stomach, the intestines, the bladder, and the uterus: hence its quantity is greater than that of all the other excretions put together. In fact, in the climate of Italy, in a person in the prime of life, who enjoys easy circumstances and takes moderate food, the perspiration which exhales from the external skin, the mouth, and the nares, is equal in weight to five eighths of the aliment taken into the body. The complete subtlety of this humor, its undisturbed equability, its great abundance, the lightness [of the body] as respects our feelings, and its increased heaviness in actual weight, its increase [in weight] after sleep,—these conditions demonstrate the most perfect health, and at the same time are the principal means of preserving health. But a departure from them is about the most certain as well as the first sign of disease, and possibly also the cause of it. (*Ibid.*, n. 426—429.) We may understand that when the sweat is increased,

and its vessels enlarged, the perspiration must necessarily be diminished, and its vessels compressed: also that this perspirable matter is converted into sweat by violent exercise and excessive heat; but that it is very greatly assisted by moderate exercise and warmth: and that nothing is more conducive to its escape than gentle and long-continued friction: that prolonged and profuse sweating causes the greatest lassitude and debility: and constantly and necessarily occurs in weak, wasted, phthisical subjects, and in those who are in a state of syncope, or at the point of death. But why is the perspiration least in a healthy person immediately after a meal, and why does it continue diminished for a considerable period? Why is it greatest between the fifth and twelfth hours after a meal? What is the reason that it is so much promoted by riding on horseback, by carriage exercise, by sailing in a boat, and above all by moving about briskly upon the ice, or in the snow?" *(Ibid.,* n. 433.)

480. SWAMMERDAM. "The external skin [of the pediculus or louse] is like stiff and transparent parchment. In many places it is marked by fine grooves or channels, in the same manner as the ends of our fingers; which grooves, when viewed with a powerful microscope, really seem to be so many divisions of pulmonary pipes. . . . Globular particles sometimes appear in the place of lines or oblong pipes. . . . In the borders of the abdomen, the skin . . . appears to be composed of regular squares, wherein circular grooves may be seen in one part, in another globules, in a third both globules and grooves, or again, only plain transparent skin dotted with points." *(Biblia Naturæ,* p. 84, 85.) The above grooves, globules, squares, circular grooves, points, &c., are represented in *ibid.,* tab. ii., fig. 9, 10.

481. "The cuticle and cutis [of the cancellus or hermit-fish], are glandular, and immediately under them is seen a fleshy membrane. On removing these integuments, we come to a great number of white, glistening filaments, which are put together with beautiful regularity, so as to cover a vast number of little parts, all exquisitely arranged, and in external appearance resembling intestines. By tracing these white filaments to their origin, I saw that they were the blood-vessels, which in the cancellus are of a white color like a cobweb. What I at first took for little intestines, were all appendages, sometimes single, and sometimes divided; these were of a tubular structure, and whitish color, and contained a matter separated into dissimilar parts, and condensed into serum and coagulum. These appendages were so very numerous as almost to cover [occuparent] the abdomen: but they were all connected together by blood-vessels. . . . They unite on each side

into two common ducts, which arise near the stomach, where the pylorus is placed, and terminate in vast numbers of cœcal tubules." *(Ibid.,* p. 201, 202, tab. xi., fig. 4, 5.)

482. The frog.—"I first discovered the epidermis in th/ skin; the true skin was lying underneath it, adorned with beautiful colors and black spots, and appearing composed as it were of globules. I afterwards separated the skin into a kind of glandular substance, which was composed of very numerous globular glands. These glands secrete the glutinous matter that is observed to be spread over the surface of the frog's skin, and that makes it so exceedingly smooth and slippery. This species of saliva has a bitter taste, and hurts the eyes by its acrimony; if rubbed upon our skin where there is any little wound, it even causes pain." *(Ibid.,* p. 834, 835.)

483. See the same Work respecting the casting and changing of the skins of worms. The worm of the hemerobios or ephemerus, p. 257—265, and tab. xiii. The cossus, or worm of the rhinoceros-beetle, p. 309. The worm of the bee, p. 422, 423. The change of the caterpillar into a chrysalis or aurelia, p. 578—584; and into a butterfly, p. [588—594], 618, 619, 620.

ANALYSIS.

484. It was a saying and belief among the ancients, that man, as well as every individual living subject, is a microcosm, or a little world moveable, acting and living in the great world or macrocosm. For, indeed, he is furnished and endowed with his own proper powers and forces, or essential conditions; with his own proper efforts and determinations; and with his own proper laws derived from his own order; so that he is complete in himself, or has all his circumstances with him, and rules them by the auspices and will of his mind, and thus, as being animated, is self-dependent in those things that concern himself (*a*). But he derives the possibility whereby he exists

(*a*) We pointed out on several occasions in the two preceding Parts of the Work, that the living body, in its determinations, directions, powers, and forces, hence in its essential conditions, is not by any means subject to the order and laws of the universe or circumambient world, but that as it derives its form, so it derives its determinations, from its own principles, just as the universe, from its own principles. Thus in Part I. we find the following words: "The animal microcosm imitates the macrocosm in all its properties; but whatever it receives from the visible and circumambient world, it withdraws from the powers of that world, and subjugates, and appropriates to itself. Consequently, to avoid being misled in investigating the body, it is necessary to put aside ideas derived through the senses from without, touching the extension of the government of the general sphere of nature to the interiors of the animal world; and to confine ourselves to the consequences of similar causes within" (n. 133). And the reader will find this confirmed throughout. It results entirely from the form of each thing, or from the determination of its essentials; for everything derives from this ground the essence that makes it what it is, and the nature

and subsists in this state, from the great circumambient world, and from the terraqueous globe, which he inhabits.

485. It is, I think, a matter of the greatest importance, to examine what this living microcosm derives from the great world of which it is an inhabitant, and from the jurisdiction of which it has in a manner departed; and what it derives from itself, and thus possesses and has control of: but we can only set forth the particulars summarily in this place. I. The atmospheres of the circumambient world lie incumbent upon the animal microcosm; press all points of its body with a force and weight proportioned to their column; and thus hold together in unbroken connexion whatever belongs to it (*b*). The microcosm itself, on the other hand, reacts against the force, gravity and

that causes it to act in the manner that it does; which is the reason why substance, because possessing its own form, is defined by philosophers as Being, separate from other things, and subsisting by itself. Our animal body, composed of divers members, is a substance in this sense, whose form, determined by fibres and vessels, according to ends and uses in the first sphere and in the last, obtains and presents the most different directions, although on the model of the directions in the universe; for the blood and the other fluids, like the food, go upwards as readily as downwards, being bound to follow the stream and gyres of the motion impressed upon them. But this matter has a wide range of applications, although perhaps it displays itself nowhere more manifestly than in the several fabrics, operations and modes of the living body. Yet inasmuch as nothing in nature can exist, or consequently subsist, from itself, hence everything must necessarily derive its origin from other things prior to itself, and thenceforth be dependent upon them: wherefore we have now to enquire in what way the body subsists from the circumambient world, and at the same time from its own active and living principle. For from it we may conclude to other substances of a similar kind, more or less simple or composite; and we shall find that the animal body is a kind of world in itself, or according to the saying of the ancients, a microcosm.

(*b*) The force of the pressure of the air is ascertained by multiplying the height of its column, and the consequent gravity, with the area of the given orifice; and according thereto, it presses [equally] against the sides, whether convex or concave, in every direction: proportioned to this is its effort or endeavor, and furthermore, its actual power. (Part II., p. 141, 142, n, 394, and note *d*.)

incumbency of the atmospheres, by similar and equal properties of its own; so that there is an equilibrium between the two, and the action and reaction are equal (*c*). The same condition obtains in the case of the atmosphere flowing into the lungs, and inspiring the body and its members with powers of motion and reciprocation (*d*). II. The atmospheres, particularly the ethereal or prior atmospheres, urge all parts of the body, consequently the whole, to their centre of gravity (*e*); and this, in order that we, pressed down in the bottom of the atmospheres, may walk upon the soil of the subject earth, and there have our dwelling-place, build up our abodes, and institute our communities. For the rest, we ourselves command the reins of our bodies, and move them to whatever quarter and in whatever direction we please, and govern the kingdom by our own laws of administration. III. Furthermore, the atmospheres minister to and serve us, by their other properties; for example, by their modifications, by which they flow into the

(*c*) This is very evident from the phenomena of the air-pump. Thus [when small animals are placed] in an exhausted receiver, the skin and the tunics under it, together with the cavities of the chest and abdomen, swell to an immense degree; and the same is the case with parts over which the air is rarefied by the application of heat and cupping-glasses; and in situations where a heavier or lighter column is incumbent.

(*d*) Respecting the equilibrium that exists in ordinary respiration, between the gravitating powers of the circumambient atmosphere, and the singular or internal powers of the lungs in conjunction with the common or external powers of the thorax, see Part II., the Chapter on the Lungs, p. 149, n. 394, and note (*n*).

(*e*) It is very clear from the spherical form of the terraqueous globe; from the antipodes, or inhabitants of the globe diametrically opposite to each other; from the centripetency arising from simple gyration, and other similar phenomena, that the above-mentioned tendencies [to centres of gravity], proceed entirely from the determination of the ether or purer atmospheres, and from the pressure thence resulting upon the least particles of the matter placed in their way; by which pressure we also are affixed to the soil of the earth. But these directions vary according as the forms of motion are different, or the motion differently impressed; as clearly proved by an infinity of experimental facts of a physical kind.

organs of our senses, and in spite of distance make objects present, and represent them as contiguous to us: these modifications we apprehend by our sensoria of hearing and sight. We appropriate them to ourselves, endow them with life, and turn them into sensations: in like manner also those modifications that come to the cognizance of the purer touch in the organs of smell and taste (*f*). IV. The atmospheres also communicate to us their changes of state,—their heat, cold, dryness, moisture, in all their variety; their partial motions, general perturbations, and a multitude of other states. We, on the other hand, oppose to these the states of our bodies, and the changes proceeding from our innermost sphere,—our heat, our cold, our temperaments, and our variously directed inclinations; lest the states of the atmospheres, entering clandestinely, should penetrate deeper than our nature allows for the purpose of enabling us to be affected by them. V. The atmospheres nourish, recruit, and constantly renovate our blood and spirit, with elements sublimed from saline matters, thus with occult food, insinuated principally through the cuticular circumference, and through the pulmonary vesicles (*g*). The earth does the same out of its three kingdoms, but through open orifices and tubes leading into the chylopoietic and sanguigenous viscera. We, on the other hand, after we have enjoyed these provisions and presents, offered and invited, either cast aside the obsolete portions of them, that have done their part, and are now unserviceable and filthy, and would pollute the chambers of the body, through pores into the field of the universe, or else discharge them through the gates of the belly. VI. The terraqueous and atmospheric world at last receives in its bosom this corporeal system, reared up and com-

(*f*) On this subject see Part II., p. 49, 50, n. 359 (*e*), and the succeeding Chapters of the present Part, on the Sensoria of Taste, Smell, Hearing, and Sight.

(*g*) Respecting the nutrition of the body by means of the pores of the cuticle, and respecting the ejection and removal of the parts unfit for nutrition, see the citations prefixed to the Chapter, [and n. 492, 493, below.] Respecting the nutrition carried on through the pulmonary vesicles, see Part II., p. 183—191, n. 406, and the Notes.

posed out of its elements, and which has now ceased to live,—buries it in the tomb, requires of it the materials it has borrowed, and again disperses them. But the soul and supreme mind of that body,—not the dust, but the celestial part of nature,—whose life that corporeal world has lived,—divested of its tenement, bidding farewell to its whilom macrocosm, betakes itself completely to its own higher sphere, of which it can be an inhabitant.

486. These considerations shew what we derive from the circumambient world, and what, from ourselves; to wit, that the world only sustains the orders and states of our bodies, as a common auxiliary, and gives us the ability to enjoy fully our proper powers and constitution. For this end it is that we are begirt and surrounded with so many coverings and tunics, by means of which, communications are maintained. In order that these communications may be explored specifically, as to the manner of their fluxion to and fro, let us unfold, one by one, the actual boundaries; that is to say, the skin proximate and contiguous to the atmospheres, its layers, and their uses.

487. Description:—The cuticle or epidermis is the most general of all the tunics of the body, covering its circumference and ultimate limits from top to bottom, or from the crown of the head to the extremities of the fingers and toes, and only terminating in the apertures, there to insinuate itself more deeply inwards: divided in the most distinct manner into little plates or scales applied one to the other, intermediate in character between membrane and horn, hence pliable and elastic; growing upon the subjacent reticulum, and by this means connected with the papillary substance or cutis. This thin, foliated tunic is diversified by furrows, ridges, and little lines, drawn and channelled transversely, obliquely, circularly, spirally; and in this manner is partitioned into diversiform areas, islands, and tuberosities, in the extremes particularly: and at the same time it is full of little foramina and imperceptible pores, coming up from the subjacent papillary and glandular congeries, whence it is perspirable throughout. Its color varies, according to temperaments, to the height of the sun at noon, and the climate; but nevertheless it is destitute of sensation, and without discernible fibres or vessels.

488. Uses:—This squamous cuticle, I. Collects the particular utilities and functions of all the tunics and strata that lie under it, represents them in itself in a general manner, and completes them: for by those tunics, and on their account, its formation and character are such as we see (*h*). II. It maintains the connexions of the parts spread under it: it sustains their changes of state: and impels them to perform their offices aright. III. Like a coat of mail, constructed of wonderful scales, folds and joints, it protects and defends the sensitive, soft and agile tunics that it covers in, against injury from the surrounding air, against its heat, cold, perturbations, and various conditions not in agreement with the state of the body; and moreover against the rough and stinging particles of its vapors, and of different fluids: and it takes upon itself in the first instance the changes to which these will give rise in the body, tempers them, and tends to break their force. IV. It institutes the proximate communications between the circumambient world, and the corporeal world that it encloses; that is to say, it admits from the air and ether comparatively pure, simple elements, which are in harmony with the natural state, and sends them down, as new aliment, into passages that lead to the blood. On the other hand, it sends out obsolete volumes of effluvia, and sweats consisting of useless lymph, brine, and rancid fat, and disperses them into the contiguous air. V. It puts together the primal singular [singularissimos] modes of sensation of the fibrillæ and papillæ, into a kind of common mode that is termed the sense of touch; which it regulates, sharpens, and blunts, so as exactly to produce the varieties

(*h*) Several strata of different substances, also called tunics, lie under the cuticle or epidermis; for example, the corpus reticulare or reticulum cutaneum; under this a papillary as well as a glandular substance, which rests upon a layer made up of fibres, blood-vessels, and filaments: then come the fat and the bulbs of the hairs; next the muscular series; then the common coverings,—the peritonæum in the region of the abdomen, the pleura in the region of the chest; and so forth. Each of these layers has both its peculiar and general uses; respecting which we shall have to treat in due course in the following pages.

that nature requires of that sense in the different parts of the body. On account of these ends and uses, this ultimate cuticular covering and bond is not a continuously-formed structure, but is framed of contiguous scales, possessing *vis inertiæ*. Let us now examine these uses separately, and illustrate and confirm them by the evidence of experimental facts (*i*).

489. I. *The cuticle collects the particular utilities and functions of all the tunics and strata that lie under it, represents them in itself in a general manner, and completes them.* The underlying series or lamellæ jointly forming the cutaneous covering, are many in number; namely, the corpus reticulare, the papillary substance, the glandular substance, the vascular congeries interwoven with nerves, and with filaments resembling lymphatics; the cellular compages of the fat; next, dense muscular fibre; lastly, the common coat of the viscera,—in the chest, the pleura, and in the abdomen, the peritonæum (*k*): with all these, placed for the most part one upon another, or set close together, are we covered round as with a coat of armor or a sheath. Each of them contributes in some peculiar manner to the defence of the body, to the prolongation of life, to communication with the ambient air, and to excercitation. But the cuticle, which is placed in the outermost sphere, draws to itself the sum and substance of the utilities of all, and this for the common good. For it is regarded by all as the boundary and closing line. For that which precedes, and which is interior, always has in view something beyond itself, in which to deposit the ultimate effect and use, and thereby to come to a rest;

(*i*) Henceforth, in my examination of different organs, I propose to observe the following plan: in the first place, to sketch a brief description of the part under notice; in the next place, simply to enumerate its uses, common and proper; and afterwards, to recur to them, and consider and explain them in detail; and to confirm them by experimental evidence in the notes or commentary.

(*k*) It will be shewn in the proper place in the following pages, that the skin, in the broad sense of the term, is composed of all the above layers, placed one upon another, and united together in a wonderful manner; for in the sequel we shall have to treat of each layer specifically.

which is the reason why the epidermis is thin, flexible, compliant, channelled with furrows, and perforated with pores (*l*). *For by those tunics, and on their account, its formation and character are such as we see.* In fact the cuticle grows and effloresces from the subjacent reticulum, and by this means especially from the papillary fibre, the glandular vessel, and the bulbs of the fatty layer (*m*), and thus arises, by continuity of connexion,

(*l*) The great expansibility of the cuticle is evident, not only from its squamous contexture and the manner in which its parts are fastened together, but also from the wonderful way in which it yields when the body swells; as in its voluntary extension and inflation in cases of obesity, in the swelling that takes place under the air-pump, and on the application of blisters; also in growing tumors, in pregnancy, in dropsy, in tympanitis, and similar diseases. "This substance," says Winslow, speaking of the epidermis, "is . . . capable of swelling and thickening, as we see by steeping it in water, and by the blisters raised on the skin by vesicatories, or any other means; and hence it would seem that it is of a spongy texture. It yields very much in swellings" (n. 477). That the cuticle is channelled with furrows is declared by Heister. "We see in it," says he, "various furrows or lines, called by Pliny, incisuræ, which are deeper in some places than in others, and exist all over the surface, but particularly in the palms of the hands" (n. 470). That the cuticle is perforated with pores, see Heister, n. 470; Winslow, n. 477; Leeuwenhoek, n. 478: and respecting the Sanctorian perspiration, see Boerhaave, n. 479. It is, therefore, flexible and yielding, in order that it may be compliant with the subjacent tunics in all the modes and particulars of their action. It is channelled with furrows, in order that by being applied to their depressions, it may obey in all respects. And it is perforated with pores, in order that it may complete the passages, and [give egress to] the perspirations.

(*m*) Our anatomists have discovered by means of the microscope, that the cuticle not only adheres to the subjacent corpus reticulare Malpighii, but also, inasmuch as the latter is firmly connected to the papillary cutis, that the cuticle is continuous with the cutis not merely by the mediation of the corpus reticulare, but immediately also; as observed by Malpighi and Ruysch. And in fact, even with the glandular substance; for the sudoriferous passages or vessels arising from the glands, perforate the cuticle; and their external orifices receive from it a singularly fine coating; according to the declaration of Winslow. "If," says he, "we narrowly examine the little pores or holes through

from both the proximate substances and the more remote. For nature observes it as a universal law, in the forms of her forces and of the substances flowing therefrom, that the parts shall construct their general, and bring it forth from their own body (*n*). And this is the reason, that when the epidermis is removed, burnt away, corroded, or taken off by cataplasms and blisters, it is reproduced almost as speedily as destroyed (*o*).

which the sweat passes, the epidermis will be seen to enter them, in order to complete the excretory tubes of the cutaneous glands" (n. 477). The cuticle also communicates very manifestly with the layers of fat; for the roots of the hairs, springing therefrom in the form of bulbs, pass afterwards through the epidermis and beyond it; and receive from it a kind of fine bark. "The fossulæ of the hairs," says Winslow, "are also furnished with . . . elongations of epidermis; and even the hairs themselves appear to receive from it a species of bark" (n. 477). From these considerations it is perfectly clear, that the cuticle is formed and produced by the several layers under it; and this, not only by the mediation of the corpus reticulare, but immediately also; wherefore it is dependent upon all; the dependence, in each case, being determined by the mode in which it is connected with each. This is the reason why the cuticle was considered by the ancients as an efflorescence of the cutis. See also note (*o*), further on.

(*n*) It is a perpetual law of nature, that her parts themselves form and acquire their general, that is, clothe themselves with a general or common coat; and this, in order that they may constitute a distinct and self-subsisting substance. Thus the parts of the cerebrum, namely, the cortical substances, surround themselves with the pia mater; the viscera of the thorax, with the pleura; the viscera of the abdomen, with the peritonæum; every member and organ, with its own covering; the fibres and bundles of fibres, with their own proper membrane: and what is more, the same is the case with all modifications and sensations, which as they creep up through the nerves to the cerebrum, like parts, form their general; as will be shewn in the sequel. For the general is in a manner the limit and bond that terminates the sphere of action of the parts; but without a fetter of the kind the parts could neither maintain their form, nor preserve their connexions, nor act within bounds. Respecting the meaning of the term, a general, see Part I., the Chapter on the Peritonæum, p. 491, 492, n. 316, *seqq*.

(*o*) On this subject Winslow says: "[The] reproduction [of the cuticle] is evident, sudden and surprising, in that it grows again, how-

490. II. *The cuticle maintains the connexions of the parts spread under it;* for it bears or embodies the ultimate ends of all, and as we said before, derives its own from all the subjacent lamellæ; hence it serves for a common bond, or for as many bonds as there are scales; that is to say, as there are particular and distinct modes of operation exerted under it (*p*). *It sustains their changes of state,* which are innumerable, and are brought to a termination or rest in the ultimate sphere; as innumerable, indeed, as the desires that affect the rational mind, the passions that affect the animal mind, and the pleasures that affect the blood or the body; or their contraries, in the shape of aversions, sorrows, and diseases: for by these causes we are softened, hardened, warmed, set trembling, benumbed, expanded, contracted; by these causes the pores are relaxed or constricted; the fibres, vessels, papillæ and glands open or close their passages; and the little skins confine or excuss their showers, vapors, and sweats (*q*). To enable the

ever often it is destroyed. . . . Hard and reiterated friction detaches it more or less imperceptibly, and presently afterwards a new portion or layer is produced, which lifts up the former layer, and this happens again and again. . . . The epidermis adheres very closely to the cutaneous papillæ; from which it may be separated by boiling water, or . . . by maceration for some time in cold water. . . . It adheres still more closely to the corpus reticulare, which is easily raised or detached along with it, so that the one seems to be a true portion or continuation of the other" (n. 477).

(*p*) If we consider the miniature actions of the subjacent layers upon the cuticle, it will be evident, that the latter cannot be divided in any other manner than into scales, if the uses of all those layers are to be received and completed by it, or the distinct modes of all their operations sustained. For the papillary forms extend at one time, and contract at another: the cuticle yields to them when extended, and runs up to them when contracted: and in like manner adapts itself to the glandular and other forms. There is not the same action in the papillæ as in the glands; nor [in the papillæ] does the same quantity of fibres act either simultaneously or successively upon the little scales, &c.

(*q*) It is of the greatest importance to consider the causes, and from the causes, the effects, of the changes in the extremes of the body;

epidermis to sustain and regulate these changes of state, and periodic disturbances of condition, it is so constructed of scales and fastenings, as to render it capable of immense dilatation, consequently of yielding to the active parts, and giving a loose rein to their spirits and forces, but still nevertheless of reacting with a certain amount of elasticity (*r*), of breaking shocks, contracting the pores, shutting them up with valves, and thus opposing its powers to the powers of all things acting upon it; for it has in it reactive force, nay true reaction, because it is united to all the parts; and it has coöperation, because it is insinuated into the windings and furrows, and even into the little lips of the foramina. *Thus the cuticle also impels the parts spread under it to perform their offices aright.*

491. III. *Like a coat of mail, constructed of wonderful scales, folds and joints, the cuticle protects and defends the sensitive, soft and agile tunics that it covers in, against injury from the surrounding air, against its heat, cold, perturbations,* [*and various conditions not in agreement with the state of the*

of the circumstances, namely, that the sudoriferous and perspiratory passages are at one time opened, at another time stopped up. For sometimes an immense body of effluvia is exhaled, while at other times all the lesser passages are closed over, so that not the smallest portion of moisture can be transmitted: and hence maladies, both of the body and of the animal and rational minds, and the actual commencement of diseases. The microcosm is not unlike the macrocosm, which at one time distends itself with vapors, at another time condenses them into clouds, and dissolves them in showers; while at another time again it rejects all moisture, and will not impregnate itself with the least vapor. But the causes by no means lie so deep that it is impossible to explore them; although their number and variety is too great to allow us to expatiate into that field at present.

(*r*) Our authors agree with us in stating that this membrane is elastic, for the scales are found to consist of a material intermediate between membrane and horn, and which is pliant and flexible, and relapses at the first opportunity into its own place and condition, being also drawn back thereto by the papillæ and glands to which it is adherent. If it be elastic, it follows, that it also reacts with a force corresponding to the action, which force indeed is slight in the parts taken singly, but considerable in all when connected together.

body;] and moreover against the rough and stinging particles of its vapors, and of different fluids. This is evident from the acuteness of the sense wherever the cuticle is thin; from its exquisite delicacy in little children, and effeminate and fair persons; and from its painful character in places where the cuticle is removed by scalds, burns, wounds, suppuration, or blisters, or where it is unduly attenuated or stretched; for in these subjects, or in these places, the papillary cutis is relatively naked, and twinges, roughens or shudders, at the least breath of air, or touch of cold, heat, or saline particles: but the contrary where the cuticle is so dense and made up of so many laminæ as to render it callous. Therefore in order that the fiery rays of the [tropical] sun may not scorch and bake the papillary fibres, but may be absorbed on the way, the epidermis as well as the reticulum are black in the Ethiopian or negro; and in order that the mitigated rays of temperate climates may sooth and excite the papillary fibres, the above parts are transparent in the European. Thus the cuticle springs up, thickens, thins and alters in exact correspondence to use; as exemplified in the horny hands of the laborer, in the naked feet of the pedlar, and in the fingers of the blind, who perceive by touch what is denied to sight (*s*). *And the cuticle takes upon itself in*

(*s*) The epidermis and the subjacent reticular tunic are declared by Heister to be black in the Ethiopian or negro, at the same time that the papillary cutis, and the layers spread under it, are white. "See Ruysch's most recent observations," says he, "upon this subject, in his *Advers. Anat.*, dec. iii., n. 8. That author has sent me, in spirit, a piece of the skin of a negro, with the cuticle partially separated from it, and hanging down. In this piece the cutis is perfectly white, as in Europeans: the outer surface of the cuticle is black, but the inner surface, where the reticulum is seen, is very black indeed. It is plain from this, that the corpus reticulare is the principal seat of the blackness in these cases. Santorinus shews the same in his *Obs. Anat.*, p. 2." (*Comp. Anat.*, n. 197, not. *a*). The cuticle is transparent in Europeans; see Winslow, n. 477. Black, as we all know, does not transmit the solar rays, but intercepts, absorbs, and extinguishes them in all sorts of irregular and obscuring crypts or little caverns, and thus prevents the scorching beams from falling directly upon the fibres and papillæ, and baking and burning them, so as to impair their acti-

the first instance the changes to which these will give rise in the body, tempers them, and tends to break their force. For the scale is intermediate in character between membrane and horn, passive, inert, superadded and growing in the way of a covering to the subjacent papillary tunic, which is active, living, and sensitive; it yields to the latter when expanded, runs up to it when retracted, and is entirely at its bidding. Perhaps the cuticle even assumes a certain interior, but obscure, change of state, in common with the strata underneath it (*t*).

492. IV. *The cuticle institutes the proximate communications between the circumambient world, and the corporeal world that it encloses; that is to say, it admits from the air and ether com-*

vity, and blunt their feeling. In this way the fibrils are protected from heat in the most careful manner. The case is different in Europeans, in whom if the rays did not pass from the cuticle to the cutis, soothing the papillæ and rousing them to life, the skin would soon become senseless; particularly in cold weather, at which time a further provision is made for the cutis, by the little rugæ and tuberosities into which it is contracted. Thus use not only adapts and builds for itself fabrics, but also conditions them, alters them, and takes the greatest care that effects shall not fall short of ends. Nor is there any objection to consider the heat as having some share in causing the blackness; yet that there is a coöperation between that heat and causes in the body, is plain from the circumstance, that the color is deepest in the part that looks inwards, as well as from the black children born of negroes in northern climates; and also from the condensation of the cuticle in laborers and artisans, whereby they are enabled to go through their work and handle their tools without too acute sensation: likewise from its increased thinness and acumen in the blind, &c.

(*t*) Throughout nature passive is associated with active; and this, in order that the passive may break and limit the forces of the active body: otherwise powers would not be bounded, they would have no sphere, and hence no form of which quality is predicable. From the connexion of the parts, there is room to conjecture that the cuticular scales even undergo a change, although of an obscure kind, in company and in correspondence with the papillæ, for they sustain the ends of the fibres, and as we before pointed out, complete the uses and effects; and if this be the case, it follows that there is nothing whatever in the papillæ but has something corresponding to it in the scales of the epidermis and subjacent reticulum.

paratively pure, simple elements, which are in harmony with the natural state, and sends them down, as new aliment, into passages that lead to the blood. This is confirmed by an abundance of phenomena: as 1. The state of the cuticle, which is sometimes so parched and thirsty, that the moisture, liquids, and oils that come to it, are dried up spontaneously, (for instance, in the palms of the hands, as shewn by the feel,) the sweats are reabsorbed, and effluvia imbibed in large quantities. 2. Pestiferous, venereal, febrile contagions, poisonous breath, deadly localities, unhealthy breezes; mercury, spirits, and the like, which come up into the blood by this channel, and infect it. 3. The liquor amnii by which the fœtus appears to be nourished for months. 4. Numerous recorded cases of asitia and adipsia; that is to say, of abstinence from meat and drink for weeks, months and years. 5. Sleep, cataphora, carus, and even ecstasis and catalepsy, which feed the blood and spirit with occult and atmospheric food. Also inebriation, stupor, exhilaration, itching, anxiety, and swooning, occasioned by mere effluvia. 6. The well-known phenomena of a similar kind, occurring in bears, vipers, frogs, balm crickets, marmots, land tortoises, snails, crocodiles, ostriches, chameleons, and other creatures (*u*), which live for a long time without food. 7. The universal vegetable kingdom, which is nourished and supported almost as much by the air as by its mother earth. And with small difference, the mineral kingdom. 8. Nay, what is astonishing, and one of nature's mysteries, only such kinds of elements are attracted from the fostering air, as are suitable, and will minister to the wants of each individual: proving that the world is bound to employ all its abundance and riches in nourishing its kingdoms, and their several subjects, according to the nature, desire, and appetency of each. Our cuticle opens the first doors for these gifts of the world to enter, and the papilla in connexion with it underneath enjoys the most exquisite perception of congruous and incongruous, and of whether objects deserve to be taken inwards (*x*).

(*u*) The reader will find this subject treated in Part II., the Chapter on the Lungs, p. 188, n. 406, and note (*l*).

(*x*) The fibre faithfully announces to the principles in the cerebrum

493. *On the other hand, the cuticle sends out obsolete volumes of effluvia, and sweats consisting of useless lymph, brine, and rancid fat, and disperses them into the contiguous air.* This is plain from the continual expiration of sweats or vapors: from the dirt that is constantly sticking to this coat, and comes out afresh, however often it is cleansed away: from the Sanctorian perspiration, as varying in its estimated quantity in different subjects, according to temperament, climate, the seasons of the year, and the times of the day; and from its retention in various diseases: from the immense number of pores displayed by the microscope; and their origin and continuation from the papillæ, the glands, the arteries, the veins, and the fat: from the perpetual vibration and respiration of the parts; and the perpetual ejection of obsolete materials to the ultimate boundaries: for in this manner the health is carefully kept in view in all the extreme points of the body, at every moment of time (*y*). Wherefore the cuticle may deservedly be considered as the most general excretory or exsudatory of the body.

and cerebellum what befalls and happens in the extremes, and thus instructed, desires and imbibes whatever is suitable, and loathes and rejects whatever is unsuitable. (Part I., p. 138, 139, n. 106, (*h, i, k*); p. 206, 207, n. 156, (*h, i, k*); p. 207, 208, n. 157, (*l*); p. 222, 223, n. 170, (*c*); p. 242, n. 185.) So also in this ultimate sphere, where the fibril puts itself forth under the epidermis, on which also the extremities of the tubules open. The case is the same with the fibre as with the tongue, which desires, loathes, attracts, rejects: whatever the latter possesses in the general, it derives from its parts; and these, from their very singulars or fibres, which have a mutual correspondence with the substances of the brain. But we are not made conscious of all touches; for example, we have no apprehension of those that are purer than the sense we can bring to bear, and the affections of which are not conveyed by the fibre to the cerebrum, but to the cerebellum; as those that occur in the stomach and intestines, and, in a word, in the viscera enclosed in the abdomen and thorax.

(*y*) I consider it superfluous to add anything more to this enumeration besides the particulars prefixed to the Chapter. The reader may, therefore, consult Leeuwenhoek, n. 478; Boerhaave, n. 479; and the other authors who have illustrated the subject by their admirable observations.

494. V. *The cuticle puts together the primal singular modes of sensation of the fibrillæ and papillæ, into a kind of common mode that is termed the sense of touch.* For the papillary villi arising at once from the fibres and ends of the vessels, are so nearly contiguous, and lean so closely upon each other, as apparently to form a continuous forest or congeries: these constitute the sensorium of touch; and place themselves in distinct bundles under the little insensible scales of the epidermis, as their proper bonds or standards (*z*). Each of the villi has its point of most acute sensation; but the epidermis puts them all together in groups under its little scales, and so gives rise to an aggregate and as it were sum of the sensitive points or acumina, which is termed the sense of touch, and which is obtuse in proportion as it is general, that is to say, formed of larger numbers of such points combined. Hence it is, that when this sensitive villosity is naked or uncovered, it is exquisitely pained by a touch from the minutest spicula of any salt (*a*); and hence this sense is more acute in those parts that are covered by thin membranes, instead of scales; as in the lips, the cheeks, the palate, the tongue, the nasal cavities, &c. And hence the epidermis *regulates, sharpens and blunts the sense of touch, so as exactly to produce the varieties that nature requires of it in the different parts of the body:* to wit, by producing and applying scales of various thinness, hardness, and extent, of greater or lesser elasticity, and of different substance, membranous, tendinous, or horny. But it is time to pass from the epidermis or cuticle to the second tunic, namely, the corpus reticulare Malpighii.

495. DESCRIPTION:—The CORPUS RETICULARE MALPIGHII, or reticulum cutaneum [rete mucosum], spread immediately

(*z*) We shall have to treat of this subject presently, when we come to speak of the papillary substance, or specifically of the Sensorium and Sense of Touch. The thin tunics of which we are now treating have no feeling of themselves, because their fibres are determined into such a form as to represent, not a living, but a dead force; a force not active, but intrinsically inert. Wherefore it was stated, that these thin tunics are assigned and associated to those under them, as passive forces are wont to be to their actives.

(*a*) On this subject, see above, n. 491.

under the epidermis, and connected and attached by the intervention of filaments to the inner surface or peridemis of its lamellæ, is seen to consist of a kind of softish mucous substance, being produced from the ultimate capilli of the vessels (*b*). This membrane, thick in some parts, thin in others, various everywhere, is most conspicuous in the palms of the hands, in the fingers, in the soles of the feet, in the face, and last not least, in the tongue. Its color is determined by the varying incidence, direct or oblique, of the meridian rays of the sun, and by the nature and character of the blood; and accordingly the reticulum may be either black, brown, chesnut, swarthy, or white. It is full of foramina or apertures, that give transmission to papillæ, ducts, emissary vessels, other vessels, and hairs.

496. USES:—The corpus reticulare, I. Serves as a basis and support to the cuticle. Also as a link and instrument of union between the cuticle and the papillary substance, the glands, the vessels, the fat, and in fine, all the subjacent parts. Thus as a mediating organ, and as an organ for transferring the modes, actions, feelings and changes of the above parts, to the scales of the epidermis; and from these scales, on the other hand, to those parts. II. It sustains, strengthens and balances the subjacent parts of the cutis. III. It gathers together scattered parts, bridges them over, gives them distinctness, reduces them to form: thus it causes everything to refer itself to a general; to proceed in successive series; to flow backwards and forwards in a certain gyre; and to conspire and tend incessantly to equilibrium and rest. Let us now consider each of these uses separately.

497. I. *The corpus reticulare serves as a basis and support to the cuticle.* For the cuticle, discriminated into parts, lies upon the corpus reticulare as a kind of continuous plane, and is connected and adherent thereto (*c*). *It also serves as a link*

(*b*) In order to explore the uses of the corpus reticulare, it is necessary to enquire carefully into its origin and connexions: the latter particularly are the means by which to judge of its function. Our authors differ some little about the origin of both the corpus reticulare and the cuticle, but nevertheless in the main they agree. But I shall endeavor to unfold and explain these points distinctly in what now follows.

(*c*) Respecting the continuation and adhesion of the reticulum cu-

and instrument of union between the cuticle and the papillary substance, the glands, the vessels, the fat, and in fine, all the subjacent parts, by means of the pores, ducts and villi; as well as by means of the vessels that arise from the subcutaneous arteries, and form a sanguineous plexus under this corpus reticulare, and by their fine terminal branches construct the substance thereof, as well as the continuous substance of the epidermis: by these structures the reticulum is united to all the little parts spread under it (*d*); and thus serves *as a mediating organ, and*

taneum to the scales of the epidermis, Heister says: "It [the reticulum] lies immediately under the cuticle, and when the latter is brought away from the cutis, either by artificial means or by accident, the reticulum adheres so very firmly to it, that a separation of the two becomes almost impossible, the reticulum seeming to be nothing more than the inner surface of the cuticle" (n. 471). The excessive blackness of the reticulum, and likewise of the inferior surface of the scales of the cuticle, affords ground to conjecture, that the substance of the former passes by continuity into the peridemis or inferior lamella of the scales. "It [the reticulum]," says Heister, "is of a white color in the European; but deep black (although the cutis is perfectly white) in the Ethiopian" (n. 471). And again, "The outer surface of the cuticle is black, but the inner surface, where the reticulum is seen, is very black indeed." (*Comp. Anat.*, n. 197, not. *a*.)

(*d*) In order to arrive at the use of the reticulum cutaneum, before we leave the present threshold and proceed further into consequences, we must by all means enquire, and if anatomy countenances the ideas suggested by an intuitive view of relations, we must explore, what the connexion is, not only between the reticulum and the scales of the cuticle, but also between it and the papillæ, or the cutis spread under it. We treated of its connexion with the cuticle in note (*c*), but its connexion with the papillary and glandular cutis, and the particular nature of that connexion, still remain to be considered. We must know both, before we can have a clear view of the relation of the one to the other. It is indeed plain from observations, that the cuticle is connected to the papillæ as well as to the corpus reticulare; as shewn by those great observers, Malpighi, Ruysch, and Winslow. Thus according to Malpighi: "The corpus reticulare is a membranous expansion, intermediate in a manner between the cutis and the cuticle; in short, made up of fibres running out through the exterior parts of the

as an organ for transferring the modes, actions, feelings and changes of the above parts, to the scales of the epidermis; and

cutis."[x]* 'In the words of Ruysch: "The epidermis, proceeding from the extremities of the cutaneous papillæ, in due time recedes from the corpus reticulare, or together with it, from the cutis vera, . . . as the new epidermis grows up." (*Thes. Anat.* iii., n. 13, not. 2.) And according to Winslow: "The epidermis adheres very closely to the cutaneous papillæ; from which it may be separated by boiling water, or . . . by maceration for some time in cold water. . . . It adheres still more closely to the corpus reticulare, which is easily raised or detached along with it, so that the one seems to be a true portion or continuation of the other" (n. 477). Yet still it does not appear from these data, what immediate communication there is between the corpus reticulare and the papillary cutis; although it is perfectly clear, that not only the cuticle, but also the reticulum Malpighianum, exists, subsists, and is reproduced from the underlying substances of the cutis. Pores, tubules, and hairs indeed do perforate this reticular membrane, and in passing through it, send and put into it some stamina and vessels: but whether these can supply a sufficient quantity of nutritious fluid to serve for its constantly fresh production and reproduction, is a subject for further enquiry; wherefore in the absence of the light of experience we must have recourse to the most probable conjectures, yet to such as experience seems in some measure to countenance. J. Fantonus asserts, that not only is there a plexus of blood-vessels spread under the papillary cutis, but also that another plexus arising from the former one, and emerging through the cutis, is spread upon its upper surface. His words are: "We see with a powerful microscope little branches of vessels disposed in a wonderful manner [upon the cutis, or, as he says,] in the cuticle, . . . as observed by Alexander Pascoli." (*Anat. Corp. Hum.*, pars i., dissert. ii., *De Communibus Velamentis*, p. 22; 4to. Aug. Taurin., 1711.) 'And Winslow says: "In inflammations we observe naturally a peculiar network of capillary vessels, more or less extended on the surface of the cutis; and minute anatomists clearly demonstrate the same thing by their fine injections, which may be looked upon as artificial inflammations" (n. 474). Ruysch also has detected the same plexus by injecting the cutaneous vessels with wax. (*Thes. Anat.* ix., n. 27; x., n. 2.) We have several reasons for believing that the corpus reticulare mainly

* I cannot find this citation in Malpighi's Works, but the following words occur in his Epistolary Dissertation *De Externo Tactus Organo*, p. 28; fol., Londini, 1687: "Not seldom I have observed a kind of rete formed by fibres running out through the exterior part of the cutis." *(Tr.)*

from these scales, on the other hand, to those parts. From which propositions we plainly see how both the reticulum and the cuticle

originates from this sanguineous plexus, particularly in the little mouths of the ducts and pores, where the vascular ramifications come up from the inferior into the superior plexus; for not only does this plexus lie close under the corpus reticulare, and not only is it enabled to insert its ends immediately thereinto; but what is most to the point, the corpus reticulare as well as the epidermis are comparatively inert substances, which shews that they are the ultimate goals of vessels, and not of fibres; for the membranes, both particular and general, all over the body, are nothing more than expanded vascular webs, although the vessels composing them split and subdivide so far, that they become too small to admit the red blood, or any gross tincture or color, unless intruded by force, or inflamed by intrinsic causes, and thus driven in: as we observed in the Chapter on the Kidneys, Part I., p. 441, n. 289 (*a*); and in many other places. This is also shewn by Winslow, where he says: "It is more probable that this vascular texture is a continuation or production of the finest capillaries of the arteries and veins, which in the natural state only allow of the transmission of the serous or lymphatic part of the blood, while the red part continues its course through the wider ramifications, which more properly have the name of blood-vessels" (n. 474). For this reason it is, that the finer the wax or injection that is used, the more stamina of the kind are penetrated and filled, until at length there is scarcely one, however small, in the whole membrane, that is not distended, so as to look like a blood-vessel. Wherefore Leeuwenhoek says on the same subject: "These vessels, which perforate the surface of the skin in vast numbers, and are covered over with a kind of little scale, are so large, that their diameter is three times that of their mouths or orifices. But when placed under the microscope, they are generally seen folded together, just as the blood-vessels in the flesh of animals are found to collapse when emptied of blood. Hence it is, that out of five and twenty such vessels . . . we can scarcely find a single one that seems pervious to the sight" (n. 478). From this ground it is that the reticular or Malpighian web derives its soft and seemingly mucous character. See above, n. 474. Furthermore, by virtue of these conditions, this corpus reticulare not only sustains the last ends of the arteries, and perhaps the first ends of the veins, and becomes gradually tenacious and tendinous as it nears the epidermis; but also communicates with all the papillæ and glands spread under it, as will be seen below, so as to be a support and stay to them: for a dense vascular growth or underwood clothes and sur-

exist, subsist and are reproduced from the parts interior to them, and are dependent upon those parts (*e*).

498. II. *The corpus reticulare sustains, strengthens and balances the subjacent parts of the cutis:* as will be evident if we consider the corpus reticulare in the light of a superextended membrane, formed of the vessels that either invest or construct the several parts underneath it; and perforated by the pores, ducts and villi that arise and proceed from the papillæ, the glands, and the fat. Wherefore the corpuscules of the cutis hang and balance from this reticular web, as cords from their fixed point, or scales from their beam and lever (*f*).

499. III. *The corpus reticulare gathers together scattered parts, bridges them over, gives them distinctness, reduces them to form: thus it causes everything to refer itself to a general.* In every unanimous society, or body that lives under the auspices of one soul, it is a law, that everything shall refer itself to some general; for the cause of the part individually is carried on in the general, and the cause of the general, or the common cause, in each individual part (*g*). For this end, the reticulum

rounds the papillæ and groups of papillæ; but enters and constructs the glandular particles. Taking these points for a foundation, we may draw a number of inferences from the connexion of the substances with each other; in particular from the connexion of the papillary cutis with the epidermis; both the immediate connexion by the ends of the vessels, and the mediate connexion by the corpus reticulare: and if these inductions be confirmed by experience, the truth of the probabilities will be confirmed along with them; just as in geometry and arithmetic, the extreme terms being given, the mean term is discovered.

(*e*) On this subject Heister says: "It [the epidermis] does not originate, as old writers supposed, from the condensation of the exhalations of the body by the air; but rather, according to Leeuwenhoek, from an expansion of the excretory ducts of the cutis; or according to Ruysch, from an expansion of the nervous papillæ of the cutis,—the papillæ forming a multitude of minute scales or lamellæ, all connected together; or perhaps, as it seems to me, from both these sources combined" (n. 470).

(*f*) Malpighi, Heister, and other anatomists, agree with us that the corpus reticulare strengthens and sustains the remaining parts of the skin.

(*g*) The more exactly simples are distinguished from each other, the more fitly they are put together into forms, and the more ordinately

cutaneum is extended over all, and attached to all, as a common bond; and by its mediation, whatever happens to any part is carried forth into the general. *To proceed in successive series,* namely, in an orderly manner from the first sphere to the last, from the innermost to the outermost, from the relatively soft parts to the relatively hard, from the active to the inert; that is to say, from the fibres to the vessels, from the vessels to the membranes, to the finer membranes in the first instance, and afterwards to the firmer and stronger (*h*): for nature never flings herself headlong from one extreme to the other; but moves forward by her degrees from beginnings to ends; and thus insinuates herself tacitly and prudently from causes into effects. This is particularly evident in the progression of the fibres towards their ultimate textures in the reticulum and in the epidermis. *To flow backwards and forwards in a certain gyre.* For when any scale of the cuticle is displaced or started, it is immediately drawn back by the plane of the reticulum, to which it is connected; in order that the reaction may be correspondent to the action (*i*), and that the effect may return to

they are related to their generals, the more perfect is the state of the member. (Part I., p. 53, n. 44 (*k*); Part II., p. 18, 19, n. 345, *q*.) In our investigation of the other organs and senses we shall have to illustrate this in greater detail.

(*h*) From the conclusion to which probable arguments led us (*d*) respecting the connexion of the substances of the cutis with the reticulum Malpighii, it follows as a consequence, that the papillary fibre, which derives from its form a condition of vitality and perfect activity, acts upon and influences the blood-vessels with which it is beset, and mediately thereby the corpus reticulare and the cuticle. The nervous fibre is the smallest and finest; next in fineness comes the capillary vessel; then the membrane woven of capillaries; then the scale made up again of such membranes compacted together. Thus there is a progression from the greatest softness to the least: likewise from the most complete activity to something like inertia. And there is a similar progression of the accidents, forces, and modes thence resulting.

(*i*) This is the reason why the cuticle is firmly connected to the corpus reticulare. See above, notes (*c*) and (*d*). For when the little scale is displaced from the papilla, it is drawn back again, by reason of the above connexion, of mechanical force and necessity, by the reticulum, which although perforated, is a continuous expanse. Thus the

the principle of the efficient cause, whether this principle be a papilla, or a gland; all points of which correspond to some more general fixed point in this ultimate plane. Thus the corpus reticulare, like a balance, causes everything *to conspire and tend to its equilibrium and rest.*

500. DESCRIPTION OF THE CUTIS. Immediately under the corpus reticulare and squamous cuticle, and adherent thereto, lies the papillary substance, mammilliform, emissile, retractile, sensitive, the true organic substance of touch; thick, hard, erect and acuminated in some parts; comparatively thin, soft, depressed and flat in others: displaying various windings and gyrations, formed of furrows, ridges, and lines, straight, oblique, curved, waving, spiral, arranged in wonderful series, and likewise subdivided: marked out and tesselated into areas, squares, globes or circles, and divers other forms, regular and irregular: in one way, for example, in the palms of the hands, the soles of the feet, the fingers and toes, and the joints of each, in the arms, the legs, the two regions of the body, the face, the forehead thereof, the cheeks, the nose, the external ear, the scalp, the part under the nails; in another way in the lips, the buccal cavity, the palate, the uvula, the penis, the glans penis, and the other more naked membranes, cavities, and organs: differently again in the œsophagus, the stomach, the intestines, the bladder, the uterus: and again in the tongue and the nasal fossæ: the forms and papillæ similar everywhere, but dissimilar in composition, array, design. This papillary substance, thus arranged in series by means of the reticular membrane or reticulum Malpighii covering it in and interposing between its parts, underneath the epidermis, according to the presence of pleasant or unpleasant touch, the intention of the mind, the changes of state in the blood and spirits, &c., either puts forth and points itself, or draws back and smooths itself, or inflames and hardens, or cools and softens, or writhes and curls. Moreover,

action returns to the papilla by a species of reflexion and so in a circle; whence reaction. The fact is demonstrable to sight, by means of tendons doubled, and bound together in a similar manner. But the contrary happens when the scale is struck, and thrust towards the papilla; in this case it is raised by the reticular plane as a fulcrum, and restored immediately to its own little natural situation.

in its furrows and sinuosities, the cutis is perforated with innumerable tubules, emissary ducts, pores and vessels, evaporating or else absorbing juices and vapors, thick or thin; or almost purely aqueous, or urinous, saline, or fatty. In addition to the above sensitive, organic forms, produced by the cutaneous fibres, there are again a number of others, consisting chiefly of convolutions of vessels, and termed subcutaneous glands, miliary glands, follicles, imbedded under the cutis, and planted for the most part upon the fat, and at the roots of the hairs, and representing oval corpuscules; furnished abundantly with both arterial and venous capillaries, and with fibres singularly plaited and intertwined; their emissary vessels reaching all the way to the cuticle, and there opening by comparatively wide orifices, as it were retracted and thinly covered with cuticular bark. Interposed between these [glands], and spread beneath the other [forms], we find a stupendous series, such as neither the scalpel nor the eye of the anatomist can ever distinctly unravel, —a series of fibres, filaments, ducts, particularly of vessels, running all over with singular serpentine flexures, advancing to the papillary cones and glandular follicles, receding from them, and by their extremities sporting round them in a wonderful manner. This is the texture and fabric of the cutis.

501. Inasmuch as the cutis embraces several species of substances, as papillæ, glands, pores, ducts, vessels, and filaments, to say nothing of hairs and layers of fat, therefore in order to unravel this complication of structures, it will be indispensable to distribute our analyses distinctly into their general heads, and these into their members, and these members into their parts. To begin with the general heads, or the general uses: the cutis, *firstly*, serves as a new source of fibres, and as an end and beginning to the vessels: *secondly*, as the foster-mother of the spirits, and the nurse of the blood; and furthermore, as the instrument for throwing out useless matters from both: *thirdly* and lastly, as the sensorium of touch. We shall now proceed to the members of these heads, and from the members to the parts.

502. Firstly. *The cutis serves as a new source of fibres, and as an end and beginning to the vessels.* I. For there are pores, ducts, and little canals, of a threefold kind, origin,

nature, and function, arising from the fibres, and from the same number of organic substances belonging to the cutis, and which as they are hollow and pervious, are both produced outwards and continued inwards. II. The pores of the first kind have their *origin* from the first composition of the cutaneous fibres. Their *nature* is, when drawn back from their apertures, to represent new fibres, which are to be named corporeal fibres. Their *function* is, to suck in the purer elements of food from the air and ether, and to carry them to their ends, and expend them upon the uses of life. III. The pores of the second kind, more properly termed ducts, have their *origin* from the pores of the first kind, so convoluted as to form a vessel; consequently from the papillæ, to the commissures or interstices of which, they run continuously. Their *nature* is, to be the first and last ends, thus the beginnings, of the arteries. Their *function* is, to expire the thin and worthless effluvia of the blood. IV. The ducts of the third kind, rather to be called little canals, have their *origin* from the subcutaneous glands. Their *nature* is, to be the beginnings of the veins. Their *function* is twofold; on the one hand to throw out of doors, away from the cutis, the vapors and sweats received from the arteries; on the other hand, to suck in the same, and insinuate them into the new formed veins. V. These three kinds of vessels do not end, excepting where the innermost coat of the arteries, and the outermost coat of the veins, place their boundaries; namely, their boundaries, but of a middle kind, in the chambers of the heart, where [all] the [vessels] come together; their ulterior boundaries, in the innermost sphere or vesicles of the lungs; but their last boundaries, where the fibres place their first, in the cortical glands of the brain. Hence the indissoluble conjunction and connexion of the last sphere with the first by means of the heart. VI. From this it appears, that the fibres springing up in the brain, again commence anew in the ultimate limit of the body, that is to say, in the cutis, and return in a gyre to their principles; and thence run forth again in company with the parent fibres into their field of uses; so that their circle is an everlasting circle or spire, in which the idea of continuity, perpetuity, or infinity, is represented. Let us now illustrate these positions one by one.

503. I. *There are pores, ducts, and little canals, of a threefold kind, origin, nature, and function, arising from the fibres, and from the same number of organic substances belonging to the cutis.* This is confirmed by the united testimony of a multitude of phenomena that are easily observable in the cutis: as 1. The innumerable small and large pores, interstices, and oscula of tubes, seen by the microscope as well as by the naked eye. 2. The equally innumerable organic forms produced by the conflux of the fibres and vessels; to wit, the simple or primitive papillæ, and the papillæ compounded or constructed of these; also the glands or follicles; which have the same number of passages or little canals corresponding to them. 3. Of which [passages] there are some, that suck in alimentitious particles from the air and ether; some that expire invisible vapors; and some again that throw out visible vapors, as for instance, the sweats, even in drops. 4. Also the three kinds of stamina, namely, the fibres, vessels, and unnamed ducts, under the papillary crust, which with various windings flow into their papillæ, little glomes, and glands, and flow out from them again (*k*).

(*k*) Respecting the filamentary, vascular, and fibrous texture that lies as a basis under the papillary substance, and affords origin to the glands as well as to the papillæ, Heister says: "The structure or substance of the cutis . . . consists of a wonderful plaiting of very tough, single, tendinous fibres" (n. 472). And Winslow: "The cutis is a tissue . . . made up of several kinds of fibres, tendinous, membranous, nervous, and vascular, the interlacement of which is the more wonderful, in that it is very difficult to unfold" (n. 473). The fact is, that in order to unfold it, we must have recourse to effects themselves, and from effects educe the meaning of this implication of so many kinds of fibres. Actual effects are more strongly visible, and more easily unfolded, than tissues as examined by the eye. Looking then from effects, it appears that these fibres, vessels, and filaments, or these three kinds of stamina, give origin not only to three kinds of corpuscules, but also to three kinds of pores or little ducts. This is perfectly evident from the cutaneous transpirations themselves; for it is beyond all doubt that there are some pores that admit and transmit the most refined elements of the ethers, and some that throw out the subtle but worthless halitus; and others again that both eructate and reabsorb the sweats. Inasmuch as this truth cannot but be plain to every one from the experience afforded in his own person, it follows, that there must be as

All of which, if they have a threefold origin, must also have a threefold function; inasmuch as the nature is derived from the parentage, and the function follows the nature. But in order that these pores or ducts may be of use in their kingdom, and yield to the community both the goods that they transmit, and the productions that they themselves originate, *they must be hollow and pervious, and both produced outwards and continued inwards.*

504. II. *The pores of the first kind have their origin from the first composition of the cutaneous fibres.* This is affirmed and subscribed by, 1. The immense numbers of fibres, almost in a state of ultimate subdivision, that enter the papillæ, distinctly terminate therein, and develop their ends into slender villi, out of which, when surrounded with a little tunic, and thus collected into a fascicle, the entire papilla is made up, and becomes a visible form (*l*). 2. The continuous interstices and passages, the same in number as the terminations or ends of these fibres or villi; presenting again the same number of perspirable channels devoted to the common use (*m*); for the fibre

many kinds of vessels and pores channelled out in the cutis; which by reason of their different functions, dimensions, and ends or destinations, and by reason of their quantity, appear so complicated as not to allow of being unfolded at all by the eyesight, but only by the rational sight, which looking from causes, sees series of complicated things in a comparatively simple light. For the condition of all things in fabrics proceeds from use. Winslow agrees in attributing this threefold use to these vessels. "The papillæ," says he, "are the organ of touch. They contribute to a universal evacuation which is in general termed the insensible transpiration. They likewise serve to transmit from without inwards the more subtle particles or impressions of certain things applied to the skin exteriorly. The first of these three uses depends upon the extremities of the nerves; the second, upon the productions of the arteries; the third, upon the continuations of the veins." *(Exp. Anat., Hist. gen. des Tegumens,* &c., n. 49.) But in order to obtain a distinct idea of all these things, we shall be obliged to consider each one separately.

(*l*) We shall speak of these terminations of the fibres, and subdivisions of the papillæ, in the following paragraphs.

(*m*) It will be shewn further on, that in the most perfect organic forms, the fibres are thoroughly discriminated from each other, and

never designs a point, still less a line or pore, without a perpetual regard of utility (*n*). *Their nature is, when drawn back from their apertures, to represent new fibres, which are to be named corporeal fibres.* For the fibres terminated in the extremes, ever intend an ulteriorly efficient cause, and in this way, perpetuity, and in their end, a new beginning, in order that their last boundary may again be something, and become their first. Such is nature's game universally in her ultimate sphere (*o*); in which respect it is comparable to a race in a circular arena, from the first barriers to the goals and columns in the hippodrome, and from these again to the starting place; or to rays that issue from luminous centres, and are reflected on the way by opposite mirrors so as to bound back again to their centres. For the simplest fibre is such a ray, which determined by the soul round the limits of its kingdom, is reflected back to its centres. Thus the fibres by no means die away in their extremes, or breathe out their noble soul or spirit, but resuscitated from a new origin, take on a new character and nature, and enter a new gymnasium of uses (*p*): never-

most distinct in their action; although bound down with their neighbors, in wonderful bonds, to perform mutual offices. Whatever is concreted or grown together, is no longer living; for life ceases with perspirability and distinction of parts, and passes proportionably to old age and death. Wherefore Hippocrates did not hesitate to affirm, that there is nothing in the living body but is a medium of perspiration and communication.

(*n*) On this subject, see Part I., *passim*.

(*o*) See Part I., p. 377, 378, 379, n. 260, (*n*) and (*o*); and Part II., p. 330, n. 455, where the following words occur: "There are as many centres as points, and as many equilibria as centres; and these, wonderfully continued or connected, form . . . perpetual gyres, which where they enfold themselves in ends, there distinctly unfold themselves from the same ends, as from their beginnings."

(*p*) Every fibre and every vessel derives its nature from its principle, for it is a continuation of its principle. Consequently, wherever any fibre or vessel produces a new corpuscule, whether such corpuscule be a papilla, or a gland, or a muscle, or an entire member, there it in a manner lays aside its former nature, and derives a new nature from its new body. So also, although it be the fibre of the brain that coalesces

theless they still pass under the form and guise of fibres; wherefore they are called after their new beginnings, *corporeal fibres.* These are the subcutaneous filaments to which no name has been assigned; and which construct the innermost, or as it is termed, the nervous coat of the arteries, as will appear from the series of proofs brought forward in the sequel. *Their function is, to suck in the purer elements of food from the air and ether, and to carry them to their ends, and expend them upon the uses of life.* That these pores are adductory or insorbent, but not expiratory or excernent, is attested by (*q*), 1. Their extreme tenuity. 2. The extreme tenuity of the elements that float about, both separately and in volumes, in the air, and particularly in the ether, and are constantly fitting and insinuating themselves into their corresponding and coequal pores. 3. The exceedingly exquisite sense in the delicate little mouths of these pores, which admonishes the soul, and the soul alone, to elect

into a papilla, yet when it returns from the papilla, it can no longer be called the fibre of the brain, but the fibre of the body, or the corporeal fibre; for as we said above, it derives its character from its new parent. The reader will find a rude delineation of the fibres that go to the skin, in Eustachius, *Tabul. Anat.*, tab. viii., fig. 1; and tab. ix., fig. 1; and which, as Lancisi says, are "nerves that issuing from the muscles, play through the subcutaneous parts." *(Op, Cit.*, Notis illustr. Lancisicis, p. 16; Colon, 1716.)

(*q*) All our authors agree that there are two kinds of pores; namely, one kind that sucks in the invisible halitus, and another kind that throws them out. Thus Heister says: "It [the cutis] exhibits certain large openings: . . . and also smaller openings, commonly called pores, which in their turn are subdivided into great and small, and give egress to the hairs, the transpiration, and the sweat; and ingress to mercury, the matter of contagions, &c. The larger pores are visible to the naked eye; . . . but the smaller pores are demonstrated by the microscope, and by the passage of mercury through leather" (n. 472). And Winslow: "The skin is perforated by an infinity of small holes called pores, which are of two kinds. Some are more or less visible. . . . The other pores are imperceptible to the naked eye, but visible enough through a microscope. Their existence is also proved by the cutaneous transpiration, and by the penetration of the subtle parts of topical applications; which two circumstances may furnish legitimate reason for dividing these pores into arterial and venous" (n. 476).

from those occult and ethereal dainties the parts that are suitable, and to reject those that are at variance with the nature of the blood (*r*). 4. The fact that these fibres in the extremes, carry nothing that they can send away; for the loss of the noble essences of which they are the vehicles, is everywhere solicitously prevented (*s*). 5. The universal nourishment of the subjects of both the animal, vegetable, and mineral kingdoms, through their cuticles, or external skins and surfaces, as shewn above by a multitude of proofs in the Analysis of this Part (*t*). These alimentitious pores can scarcely become visible by any power of the microscope, inasmuch as their delicate little mouths are set and ingrafted in the little lips of the larger ducts.

505. III. *The pores of the second kind, more properly termed ducts, have their origin from the pores of the first kind, so convoluted as to form a vessel; consequently from the papillæ, to the commissures or interstices of which, they run continuously.* This position receives support and assent from, 1. The next compages or fasciculus of fibres, which is composed of the least papilliform fibres, as its principles, and constitutes the unity of the sensorium, or the simple sensoriolum of touch, and is properly called a papilla. Wherever one of these [fibres] is united to another, and to its associates, there we find, not a mere fissure, but a passage in the form of a tube: thus, by

(*r*) See Part I., p. 206, 207, n. 156, (*h, i, k*); p. 207, 208, n. 157 (*l*); p. 242, n. 185.

(*s*) In truth the fibres are so fearful of the loss of their spirits, that they contract at the least touch, and block up the way: and they collect the scattered spirit, and send it back into the blood through the lymphatics and the thoracic duct; (Part I., p, 221, 222, n. 169 (*a*); p. 237, 238, 239, n. 181, 182, *n*): which [namely, the contraction of the fibres] is one of the causes of unpleasant sensation.

(*t*) Namely, in n. 492. The vegetation of certain trees, which are nourished by the air more than by the earth, is an additional proof of this point. I allude to resinous pines, and similar shrubs, which are redolent of aromatic juices in the most barren sand, and come in the naked clefts of mountains, exposing their very roots to the air: not to mention species that are green and flourishing for years, although hanging in mid-air.

virtue of a constant and inviolable law in the universal kingdom, the simpler fibre is turned, by a process of conglomeration, into a little canal or vessel (*u*), so as not only to be of use in its simple, but also in its compound. 2. The innumerable little mouths and vessels seen under the microscope, perforating this papillary cutis, and still wandering further, and scarcely to be computed by ordinary numbers, but rather by myriads (*x*). *Their nature is, to be the first and last ends, thus the beginnings, of the arteries.* This is borne out by, 1. The infinite stamina continued from the little arteries, which come to light when expanded by wax injections, and present the appearance almost of one uninterrupted plexus, so as even to conceal the papillary fibres from view (*y*). 2. These are most particularly and beauti-

(*u*) It will be clearly shewn in the Analysis of the Cerebrum, that the simple fibre never proceeds solitarily, but as soon as it has passed out of its parent cortical gland, rolls itself into a kind of little canal, which is termed a compound fibre; and this again into a fresh canal, or into a blood-vessel; and the blood-vessel, into follicles, glands, and the like hollow glomes, so as to produce again a new vessel, and so on: shewing that there is a perpetual derivation, composition, consequently, convolution of simples. There is nothing but conspires to a new organic form, in order that it may take therefrom a new character, and produce a use suitable thereto.

(*x*) "By repeated observations and experiments," says Leeuwenhoek, "I obtained such results, that I can state for certain, that in the whole field of the external skin of the body there is no space but what is perforated with excretory vessels" (n. 478). And Boerhaave observes, "There are . . . exhalant vessels, . . . opening obliquely, and of such exceeding fineness, that Leeuwenhoek reckons that 125,000 of them open in a space that may be covered by a single grain of sand. By these vessels a most subtle humor is constantly transpiring from every point of the body, which humor is named the Sanctorian perspiration, from its discoverer, Sanctorius" (n. 479).

(*y*) "The cutis . . . consists," says Heister, ". . . of vast numbers of blood-vessels first properly brought to light by the stupendous injections of Ruysch" (n. 472). And according to Ruysch himself: "The vessels of the cutis are so numerous, that when injected, it becomes perfectly red, so that it seems to be made of nothing but vessels." (*Thes. Anat.* viii., n. 90.) See also his delineation of these vessels, *Thes. Anat.* ix., tab. iii., fig. 2. There are two vascular plex-

fully seen in the diminutive bodies of embryos and infants, where the cutis exhibits nothing but sanguineous redness and arterial terminations. 3. The passages and ducts traversing the papillary covering, seen by the microscope, to the admiration and edification of the anatomist, and which eliminate the subtler impurities, and thus are continuous with the arteries, whose office it is to excrete (*z*). 4. The well-known origin of all the arteries from fibres born in the brain; although, in order that the arteries may be vessels of a corporeal stock and nature, they require to be composed of fibres that derive this nature from new beginnings. These fibres, so convoluted as to form a vessel, go to prepare and construct the innermost coat of the arteries, which is their first coat and their last (*a*). 5. The same thing is attested by the existence of the arteries in the

uses, an inferior and a superior: respecting the latter, see n. 497 (*d*). If we take into account the wonderful continuity of the blood-vessels, and their universality in the cutis, so that they even tinge the papillary substance, we may conclude without hesitation, that the papillæ of touch are not made up of nervous fibres alone, but also of capillaries or blood-vessels. And if we may reason from comparative anatomy, that is, from similitude of fabric in other parts of the same kingdom, we shall find, that the ultimate ends of the arteries invest the fibres forming the papilla in the form of a soft bark or tunic, and defend them from being exposed naked to touch, and so conceal them.

(*z*) "I pared several lamellæ from my skin," says Leeuwenhoek, ". . . and saw . . . that a little piece of skin . . . was perforated with innumerable pores; which I distinguished with great clearness, the case being much as if we were to prick a little piece of paper with a very fine needle, and see the sun shining through the holes. . . . A piece [of skin] not above an inch long must hold a thousand vessels; . . . and a square foot of skin, a hundred and forty-four millions" (n. 478).

(*a*) We shall have to demonstrate at some length in another place, that the innermost or nervous coat of the arteries runs continuously from the beginning to the end of their canals. Here we shall only observe, that the muscular coat is dropped in the least arterial capillaries, consequently also the vascular, which serves the muscular, and the glandular likewise: for all the exterior coats are here constructed for the use of the interior. How the innermost coat of the carotid arteries, in the cerebrum, is implanted in the cortical substances, will be shewn in the Part on the Cerebrum.

chick, as examined in the egg during incubation, where the beginnings of the vessels are found to spring up at a distance from their heart, and in the extremes of the body (*b*). 6. Lastly, the vast numbers of similar origins, not only in the outermost goals of bodies, but also everywhere in the innermost stadia of the viscera, as in the cavities of the stomach, the intestines, and many other organs (*c*); and even in the trunks of the arteries themselves. *Their function is, to expire the thin but worthless effluvia of the blood*, consequently to be excretory or educent pores or ducts. This we are taught by, 1. The Sanctorian perspiration, brought to light by a mass of observations extended now over a long period of time; also by the vapors

(*b*) On this subject Malpighi says: "It is very difficult to determine by the senses whether the existence of the blood precedes that of the before-mentioned heart.* . . . But this much certainly is visible, that the blood or sanguineous material does not possess from the commencement all those things that are afterwards found in it. . . . It seems clear, that the ichor, or material above alluded to, which afterwards becomes red, precedes the motion of the heart; but that the heart, as well as its motion, precede the rubefaction of the blood." (*De Formatione Pulli in Ovo*, p. 5, 6; fol., Londini, 1686.) "After thirty-eight hours of incubation, . . . the umbilical vessels were seen ramifying about with varicose and reticulated twigs, but they were not yet produced as far as the heart, &c." (*Ibid.*, p. 4, 5.) See also the same citations in my *Economy of the Animal Kingdom*, n. 242. For the heart is the common receptacle of the blood, and the common starting-place of the arteries and goal of the veins. What is common grows out of its parts, but not *vice versa:* consequently the heart grows out of its arteries and veins; and for this reason, the heart is not seen to arise in the breast of the chick until after some days of incubation have elapsed.

(*c*) "The exhalation of this humor," says Boerhaave, "is carried on by the whole external epidermis, as well as by the cuticle of the mouth, the nares, the fauces, the larynx, the lungs, the œsophagus, the stomach, the intestines, the bladder, and the uterus: hence its quantity is greater than that of all the other excretions put together" (n. 479).

* *He had said previously, "I think that these vesicles, pulsating in succession, constitute a true heart."—(Tr.)*

plainly seen to exhale in the form of a wavy smoke from the scalp when denuded of hair (*d*); by the above perspiration being different and mutable according to the times of the day, the seasons of the year, age, sex, climate, the weather, and the changes and affections of the body (*e*). 2. By the anxiety felt when these passages [or ducts] are obstructed, the conflict of the blood and spirits with heterogeneous matters; then the distress of all the parts in the fabrics, and of the fabrics in their universe, premonitory of the secret presence of disease. 3. The law demanded by necessity of use, that these ducts should be continued from the arteries which alone expunge the worthless parts of their blood, and should attain their outlet through the papillary fibres, which can be expansile, contractile, and susceptible of infinite states of change (*f*), and can thus be the genuine regulators of the matters to be perspired.

(*d*) "The cutaneous exhalation," says Winslow, "becomes very sensible, when we apply the ends of the fingers, or the palm of the hand, to the surface of a mirror, or of any other polished body; for such surface presently appears dulled, and covered with condensed vapor. . . . If we look at the shadow of a bare head . . . upon a white wall, . . . we shall see very distinctly the shadow of a flying smoke issuing from the head and mounting upwards." (*Exp. Anat.*, *Hist. gen. des Tegumens*, &c., n. 56, 59.)

(*e*) Since these points depend purely upon observation, it will be sufficient to quote the descriptions given by those who have had experience on the subject. "In the climate of Italy," says Boerhaave, "in a person in the prime of life, who enjoys easy circumstances and takes moderate food, the perspiration which exhales from the external skin, the mouth, and the nares, is equal in weight to five-eighths of the aliment taken into the body" (n. 479). And Winslow says: "The calculation of the celebrated Italian [Sanctorius], is not found to hold good with respect to other climates: as shewn by the long courses of experiments undertaken by M. Dodart and M. Morin, Members of the Royal Academy of Sciences; and by Dr. James Keill, as given in his *Statica Britannica.*" (*Op. Cit.*, *loc. cit.*, n. 58.)

(*f*) It was pointed out above, how susceptible the papillary fibre is of changes of state. For in order that the perspirations may be conditioned according to every state of the body, and affection of the animal mind, and interior senses, to which the province and charge of providing for the health of the body is entrusted, it is necessary that they

506. IV. *The ducts of the third kind, rather to be called little canals, have their origin from the subcutaneous glands,* termed otherwise miliary glands, follicles, and cutaneous receptacles; which glands beset the cutis in very great numbers (*g*),

should pass through the papillary substance; because this substance, being sensitive in even its leasts, is either expanded or contracted according to every affection of inmermost nature, and correspondently, the little passages or pores that traverse it, are either opened or shut. Hence the causes of the varieties of the perspiration, namely, the proximate and remote causes of the stopping or unstopping of its pores. For nothing whatever is done in firsts or principles that has not its corresponding effect in extremes. Wherever the fibre goes, it always carries with it the animus of its principle, and brings that animus forth in ultimates, and deposits it in some effect resulting therefrom.

(*g*) In order that we may not, with Ruysch and Heister, call in question the subcutaneous glands, because they arise from vessels, I will here bring forward a few vouchers for them, taken from the eye-witness of the most sagacious anatomists. The observations of Malpighi and Steno on the subject are too well known to require statement. "Underneath the cutis," says Boerhaave, "upon the fat, all over the circumference of the body, lie what are called the miliary glands; thickly set; furnished with an artery, vein and nerve; and giving forth an excretory vessel, which . . . discharges the sweat by an open orifice under the epidermis; and is covered by a hollow, elevateable, roundish valve. . . . This [vessel] is the principal organ for the excretion of the gross sweat; there being other vessels, namely the vascula Ruyschiana, for pouring out the thinner moisture" (n. 479). And Winslow says: "These granules are partly imbedded in the substance of the cutis, in little fossulæ. . . . By macerating the skin in water, or any other convenient liquid, these granules . . . become very visible. . . . The late M. Duvernay clearly demonstrated to the Royal Academy of Sciences, the structure of some of these cutaneous glands, which appeared like circumvolutions of small intestines, plentifully supplied with capillary vessels" (n. 475). Nor are they visible only in the skin of large animals, but particularly so in the skin of small animals and insects, as the frog, the cancellus, and many other creatures. Respecting the frog, Swammerdam says: "I . . . separated the skin into a kind of glandular substance, which was composed of very numerous globular glands" (n. 482). And respecting the cancellus, he remarks that its "cutis" is "glandular," and that "on removing these integuments [the cuticle and cutis], we come to a great number of white, glistening filaments,

and have inserted into them the arterial and fibrous ends, wonderfully intertwined (*h*). Therein the artery conceives the vein, that is to say, the little innermost tunic of the former produces the outermost tunic of the latter (*i*); giving rise to new threads or staminula, which in conjunction with the parent arteries, and with the aid of the nervous fibre, generate a glandiform spring, out of which the vein is derived and born; which vein, by virtue of its origin, becomes of a passive nature and character, analogous to the female sex, alluring into it the juice of the artery as the male, and dispensing this juice upon new uses of life. The same thing occurs in all the other extremes; whether in the cavities, which are the innermost, or the convexities, which are the outermost; for the ultimate goals of the running fibres are in both (*k*). Consequently, *their nature is, to be the beginnings of the veins. Their function is twofold; on the one hand to throw out of doors, away from the cutis, the vapors and sweats received from the arteries; on the other hand, to suck in the same, and insinuate them into the new formed veins:* so that these glands are in a manner Vertumni, or double-jointed hinges affixed to the arterial door-posts, to bend either

which are put together with beautiful regularity, so as to cover a vast number of little parts, all exquisitely arranged, and in external appearance resembling intestines. By tracing these white filaments to their origin, I saw that they were the blood-vessels. . . . What I at first took for little intestines, were all appendages; . . . these were of a tubular structure" (n. 481). The breaking forth of the sweat at stated intervals, is another proof in favor of these glands; for without regulative glands, the sweat would break out direct from the arterial extremities in an uncontrolled stream; and perhaps even a sanguineous humor might frequently be thrown out with the serum when the cutis is violently inflamed.

(*h*) See Duvernay's description as cited by Winslow (*g*).

(*i*) In similar glomes or ultimate boundaries of the vessels, the innermost coat of the artery makes a turn [versuram faciat], and passes over into the outermost coat of the little vein. (*Economy of the Animal Kingdom*, tr. i., n. 223.) For the innermost coat of the arteries is shewn by the unanimous consent of our authors to be similar to, and continuous with, the outermost coat of the veins.

(*k*) See above, note (*c*), the citation from Boerhaave.

outwards or inwards, and either spit out the recrementitious serum into the air (*l*), or else pour it immediately by a short turn into a continuous vein. That these glands have a twofold office, or amphibious nature, is shewn by, 1. Their origin from the arteries, and the origin of the veins from them by a turn [per versum] (*m*). 2. The evident production of their emissary vessels into broad sudoriferous pores, of which 3. The orifices are observed with separated lips, and both retracted inwards and extended outwards (*n*). 4. The sudoriferous showers, clogged

(*l*) It is stated by Verheyen, on the authority of Steno, that each of the pores of this kind has a gland under it, from which a sudoriferous vessel arises. "Steno observes," says he, "that each of the pores has it own gland beneath it, from which arises a sudoriferous vessel that terminates on the outer surface of the skin." (*Corp. Hum. Anat.*, tract. ii., cap. iii.)

(*m*) Ruysch has plainly shewn by his stupendous injections, that the arteries fix their boundaries, and as it were their footstays, in these and similar glands; and for that reason Ruysch expunges these granules from the list of glands. Malpighi attributes to them an artery and fibre, but no vein. "Malpighi," says Verheyen, "traces an artery and nerve to each gland, to which doubtless should be added a vein." (*Ibid.*) This affords a warrant for the opinion, that none but the smallest, none, in fact, but impenetrable venous stamina, exist in those glands; and that the vein is formed by these stamina being put together so as to make a vessel or tubule; agreeably to our declaration. I am not aware that it has ever been really proved to ocular demonstration, that any little mouth of a vein reaches as far as the scales of the epidermis; while on the other hand it is evident from an infinity of phenomena, that not only the subtle particles floating in the atmospheres, but the grosser also,—aqueous, oily, and the like, and especially the spirituated particles, are absorbed; and in fact that halitus and sweats are reabsorbed after having been once expired, to the sensible disturbance of the body affected by them.

(*n*) This is an observation of Morgagni,[x] given in his very words, excepting that he says that these orifices appear more retracted than extended: from which it is very clear, that the emissary vessels put forth by the glands, are intended not only for throwing out the effete humors, but also for seizing the same, and carrying them inwards. And this double action is in use not merely in the skin, but also in the intestines, where the vessels as well as the glands enjoy both powers;

with stinking fatty dirt, which they eructate at intervals from the arteries. 5. And the similar showers that they reabsorb at

in that the arteries lick and drink the juices and chyles with their little lips in like manner as the veins. According to Heister: "Albinus has observed, that the veins of the intestines may be filled with injection through the arteries, and the arteries through the veins; a fact which, [as he says,] gives rise to singular speculations." (Part I., p. 174, n. 134, *l.*) And the same thing is of no such very infrequent occurrence in these games of nature. For it is not uncommon for one and the same vesicle, like a little heart, to protrude the humor received, both inwards and outwards; exactly according to the requirement of necessity, or according to use, which involves in it the whole plan and detail of actions. This is exemplified in all the arterial vesicles or little hearts of insects, which propel the blood at one time onward, at another time backward; as observed by Malpighi in the silk-worm. "The motion of the hearts," says he, "acquired during the first days of [the existence of] the aurelia [or chrysalis], still continues; that is to say, the juice is expressed from above downwards, and propelled by successive systole. But this natural course is by no means so constant, but that it may be altered by even a slight cause; perhaps indeed nothing can be less constant. . . . I remember having observed in the butterfly, a motion of the heart . . . from below upwards; and then, very shortly afterwards, the starting-places were changed, and the motion was directed from above downwards, and lasted a long time. . . . I gathered another observation from the aurelia immediately after it had been formed. The motions of the hearts were directed from the head to the lowest part; then from the latter to the middle; from which the fluid was sent back by propulsion the opposite way, like a hand-ball, to the tail; and this game of nature lasted in this manner for no inconsiderable time, until two motions, directed to the opposite ends, burst forth from the middle, upwards and downwards," &c. (*Dissert. Epistolic. de Bombyce*, p. 38, 39; fol., Londini, 1686.) For further information on the subject, we refer the reader to our *Economy of the Animal Kingdom*, tr. i., n. 244, *ad fin.*, where he will find Malpighi's account at length, full of interesting phenomena. Nor in follicles of the character of these subcutaneous glands, is the one office repugnant to the other. For if the artery pours forth its recrementitious humor into the gland, it can send it away in either direction, either through the emissary duct into the air, or else into the continuous venous channel. The road is open both ways, and is constantly trodden and in use towards the vein, whether desiring to feed itself from the air or from the artery.

stated times, and drink in to the last drop, so as to leave the surface dry, (as perceived by feeling in the palms of the hands;) whereby they slake the thirst of the veins that are continued from them (*o*). 6. Thus these canals, in their twofold nature and function, correspond to the two first kinds of pores, both those that attract, and those that excrete; and act at once with both, whenever the simpler and more distinct nature requires the assistance of its compound and more indistinct nature.

507. V. *These three kinds of vessels do not end, excepting where the innermost coat of the arteries, and the outermost coat of the veins, place their boundaries.* For wherever nature places her last, there also she places her first: she draws the outermost from the innermost, and produces the innermost into the outermost; hence in her organic forms we always find the idea of continuity, perpetuity, and spiral. She puts forth the fibres from the first little starting-places to the last goals in the body; there she transposes the outermost surfaces of the fibres into the innermost surfaces of the arteries, and these again into the outermost of the veins (*p*): wherefore the artery commences from its little innermost coat,—from what is termed the nervous coat,—and the vein commences from a similar outermost coat (*q*); each of which coats continuously follows its vessels all the way to the ultimate boundaries: *namely, to the boundaries, but of a middle kind, in the chambers of the heart*; for in the left ventricle of the heart all the arteries of the body come together with their blood and their coats, of which coats the

(*o*) See the experimental proofs brought together to shew that the cuticle sends out obsolete volumes of effluvia, and sweats consisting of useless lymph, brine, and rancid fat, and disperses them into the contiguous air (n. 493). And that it institutes the proximate communications between the circumambient world, and the corporeal world, and sends down new aliment into passages that lead to the blood (n. 492). See also the citation from Winslow, n. 503, note (*k*), *ad fin.* With respect to the valves of Steno, they are denied by Heister and other anatomists.

(*p*) As shewn to be the case just above, where we spoke of the generation of the arteries from the fibres, and of the veins from the arteries.

(*q*) See above, note (*i*).

innermost invests the parietes of the heart, and there makes a single and continuous membrane out of all these myriads of beginnings (*r*). But this coat does not rest long in the innermost parts of the heart, for instantly it throws itself, by imperceptible passages and pores, towards the outermost surface of its heart, and again expands, and gathers up and continues itself into the innermost coat of the pericardium, and by this returns to the outermost coat of the veins (*s*): thus again, in these middle boundaries, as in the first, it conjoins the inner-

(*r*) That the innermost coats of the arteries brought from their beginnings, are continued to the interiors of the heart, Lancisi shews in the following words: "This [innermost] coat of the arteries," says he, "answers to that which invests the inner surface of the ventricles of the heart," &c. (*De Motu Cordis, &c.,—De Aneurysmatibus*, lib. ii., cap. i., prop. vi.; and in our *Econ. A. K.*, tr. i., n. 121.) Respecting the same coat, Verheyen says: "The . . . inner coat of the arteries is the thinnest, and almost purely membranous, or, if the reader pleases, nervous. Its fibrillæ run longitudinally, at right angles to the annular fibres of the preceding coat. These fibres are thicker near the heart." (*Corp. Hum. Anat.*, tract. i., cap. iv.; and in *Econ. A. K.*, tr. i., n. 116.) For it is clear from the anatomy of the arterial coats, that the other coats, muscular, glandular, and vascular, are taken on afterwards, and that the one is constantly the basis of the other; wherefore they all disappear towards the capillary ends, the innermost alone remaining.

(*s*) Lancisi shews in his Treatise *De Motu Cordis*, &c., that the innermost coat of the heart is propagated through imperceptible pores, to the outermost, and from thence to the innermost coat of the pericardium; or what amounts to the same thing, that the innermost coat of the pericardium is continued to the outermost coat of the heart, and the outermost coat, to the innermost of the same. Suffice it to give his declaration respecting the continuation of the innermost coat of the pericardium to the outermost coat of the heart, and also to the outermost coat of the veins. "The internal coat [of the pericardium]," says he, ". . . is reversed, and doubled back towards the heart, so as to invest those portions of the great vessels that are contained within the pericardium; and it is also spread and extended, so as to cover the coronary arteries, and the whole surface of the heart." (Part II., p. 220, n. 419.) From this we may see, not only what a connexion of parts there is in the body by means of the vessels, but also what a circuition there is, or a going and returning of things to their beginnings.

most coat of the arteries, by a stable bond, with the outermost coat of the veins. But nevertheless, it does not stop here; this is only the middle stadium of its field and course; it has in view a further goal, namely, the last in the body, which again is the first. Therefore, *it ascends* by the innermost coat of the pericardium, around the bronchia and their great vessels, *to the innermost reticular meshes and vesicles of the lungs* (*t*), and there stops at last. Oh! the astonishing and infinite game that nature plays in her organic gymnasium! This, however, is the manner in which it ties its knots in the lowest sphere, or in the body; *but it places its very last boundaries where the fibres place their first, that is to say, in the cortical glands of the brain,* or in the principles and centres of the superior sphere: for thither the carotid artery arises with the same innermost and first coats of the arteries; and after it has connected them, under the pia mater, with the outermost coats of the veins, at length engrafts them upon the principles of the fibres, or the before-mentioned cortical glands (*u*). *Hence the indissoluble conjunction and connexion of the last sphere with the first by means of the heart.* For thus the discriminated quantities, or the myriads of arterial and venous principles, unite around the heart into one continuous quantity, or common membrane; which proceeding again onwards from this spot, resolves itself into discontinuous or discriminated quantities in the lungs and in the brain (*x*).

(*t*) On this subject see Part II., p. 222, 223, n. 420; p. 228, 229, n. 421 (*m*); p. 286, n. 440 (*e*).

(*u*) This will be proved by an abundance of experimental evidence in our next Part, where we treat of the Cerebrum.

(*x*) From this ground, agreeably to the mechanical and physical laws of motion, may be deduced and comprehended the cause, why the cardiac wheel, placed in the middle, and as it were suspended from the ends of its cords, is enabled to give forth such inconstant vibrations, which in nowise conform to the more constant and slow vibrations of the lungs and brain; (for that the respirations of the lungs and brain are synchronous, has I imagine been sufficiently proved in the foregoing analyses): namely, that the cause is, that the little machine of the heart hangs in the middle, and this, not from distinct threads, but from the pericardium, which is a continuous membrane; and is thus suspended and so balanced by them in their middle. By which won-

VI. *From this it appears, that the fibres springing up in the brain, again commence anew in the ultimate limit of the body, that is to say, in the cutis, and return in a gyre to their principles; and thence run forth again in company with the parent fibres into their field of uses; so that their circle is an everlasting circle, or spire, in which the idea of continuity, perpetuity, or infinity, is represented.*

508. SECONDLY. *The cutis with its miniature viscera and intestines, serves as the foster-mother of the spirits, and the nurse of the blood; and furthermore, as the instrument for throwing out useless matters from both.* For I. The pores of the first kind, simply bibulous and feeding, immediately convey the elemental food that they sip from the ethereal and celestial auras, through their corporeal, thus venous, fibres, in part to the cortical glands of the brain, which are the prime laboratories of the spirits; in part to the pulmonic cells, which are the little refectories of the blood, and the preparatories that change it from venous to arterial; in part to the left chamber of the heart,—the starting place from which the arterial blood comes forth: use and want regulating and dispensing the quantity and quality of this aliment. II. But the pores of the second kind, which we have termed ducts, simply expiratory, put to flight and exterminate the injurious and recrementitious matters that infest the purer blood [and the spirit], that irritate the interstices of the fibres and of the nervous fascicles, and that beset the lesser cutaneous parts. III. The ducts of the third kind, more properly called little canals, in nature and office both excretory and adductory, thus hermaphrodite [bigeneres], purge the arterial blood, the subjacent fat, the muscles, and the integuments of the viscera, that is to say, the peritonæum and the pleura, of their grosser impurities, when the outlet through the

derful and Divine contrivance, the heart is enabled to give forth dissimilar motions, which do not flow into the respiratory motions of the lungs and the animatory motions of the cerebrum in any other than the most general manner. Respecting the covenants that there are in another way between the heart and the lungs, in order that each, excited by its own causes, may perform its motions without interruption from the other, see Part II., p. 235—238, n. 423; p. 339—341, n. 457 and notes.

other doors provided by nature is not available. At stated times also they seek out and suck in the purer lymphs, or even the thicker vapors, from the air itself; and pour them into the continuous veins. IV. And this, unintermittingly, with a kind of systolic and diastolic action synchronous with the pulsific movements of the heart and arteries, which seizes all the cutaneous parts, the little arteries, the papillæ, and the glands, and rouses them to their functions. V. But with infinite variety, according to all changes of state arising from sensation and affection, outermost, innermost, and intermediate. VI. By an attentive review of the above positions, a knowledge of many of nature's secrets is brought to the light of our understanding, although still in only an obscure manner; for instance, we understand in this way, the derivation, production, and generation, in living bodies, of the inferior and ultimate universal essence from the superior and supreme, &c. &c. Let us now consider the members of this head one by one.

509. I. *The pores of the first kind, simply bibulous and feeding, immediately convey the elemental food that they sip from the ethereal and celestial auras, through their corporeal* (*qq*), *thus*

(*qq*) Respecting these pores and fibres, see n. 504. They are called venous, because they flow back from the last boundaries of the body to the first in the brain; those being arterial that flow down from the first boundaries in the brain to the last in the body. The former bring the aliments for the conception, generation, and nutrition of the spirits, as the veins for the conception, generation, and nutrition of the blood; but the latter diffuse the spirit thence produced through the universal kingdom, as the arteries diffuse the blood. These fibres mount by the innermost coat of the arteries, which they construct, all the way to those ultimate boundaries (n. 507). Respecting this coat, Verheyen says: "The . . . inner coat of the arteries is the thinnest, and almost purely membranous, or, if the reader pleases, nervous. Its fibrillæ run longitudinally, at right angles to the annular fibres of the preceding coat. These fibres are thicker near the heart" (n. 507, *r*). In the two next Parts it will be shewn, that the same coat is also continued through the carotid and vertebral arteries to the cortical glands of the cerebrum and cerebellum, and to the cineritious glands of the medulla oblongata and medulla spinalis. Lancisi also seems to have suspected that it conveys alimentitious humors of the kind alluded

venous, fibres, in part to the cortical glands of the brain, which are the prime laboratories of the spirits (*rr*). For there are three universal essences of the body,—the soul, the animal spirit, and the red blood; and the same number of determinations, fibres or vessels, out of which our animated bodies are fashioned organically and put together. One essence principally derives its being and its possibilities from another more universal and higher than itself; hence the animal spirit derives its character, and its capability of living and acting as it does, from its soul; but the blood, from the spirit (*ss*), which spirit is thus the medium by which the soul is enabled to enter the depths of the blood (*tt*), and by the blood to be infused into every part. But

to, or prevents them from flying off; for speaking of the innermost coat of the arteries, he says that it "answers to that which invests the inner surface of the ventricles of the heart, and which is composed of a very thick growth of villi, and alone keeps in the more subtle and volatile particles, which without it, would doubtless escape with ease in great quantities." (*De Motu Cordis, &c.,—De Aneurysmatibus*, lib. ii., cap. i., prop. vi.; and in our *Economy of the Animal Kingdom*, tr. i., n. 121.)

(*rr*) It is the common opinion of the best informed anatomists, that the cortical glands produce the so-called animal spirit; and reason itself supports their view: for these glands are prefixed to the fibres in the manner of supreme heads; and inasmuch as the fibres convey this spirit, and exercise the vital functions of the body by its means, therefore it cannot possibly be derived from any other springs, organs, or laboratories than the cortical glands. But we shall treat of this subject in the Part on the Cortical Substance and the Fibre. These vessels, the corporeal fibres, do not terminate until they arrive in the cortex of the cerebrum (n. 507).

(*ss*) The reader may see this a little more fully explained in Part I., the Chapter on the Peritonæum, p. 487—489, n. 313, 314 (*g*).

(*tt*) It was shewn and illustrated by many considerations in our *Economy of the Animal Kingdom*, in Treatise I., on the Blood and the Heart, that the animal spirit enters as the principal substance into the red blood, and constitutes its vital essence (*Ibid.*, n. 37—42); and that thus we have to consider three degrees of composition in the red blood, which degrees should be perceived distinctly, since the blood is distinctly compounded into each, and divided into each. (*Ibid.*, n. 91, 92; *seqq.*) See also what we said on the same subject in the present Work, Part II., p. 190, n. 406 (*o*).

in order for this spirit to exist, choice dainties must be imbibed from the celestial auras, and the nectar of the ethers must be drank; in other words, volatile chyles must be attracted, and carried by the purest vessels, namely, the pores now under consideration, all the way to the little factories, where, by a high process, the spirits are elaborated (*uu*). Hence the origin of the spirits, like that of the blood, is by means of aliments converted into chyle; except that in the latter case the process is performed in chemical organs of a different construction, as the stomach, the intestines, the liver, and the other viscera. Consequently an analogous conception, generation, and nutrition, is appointed for both,—for the spirit as well as the blood,—but for the one, from invisible or ethereal aliments, sucked in by the innumerable little mouths of the skin; for the other, from visible food, taken from the earth's three kingdoms by the one mouth of the lips. The spirit, thus conceived, generated and nourished, is instantly poured forth by its cortical glands into the fibres with which they are connected,—into the medullary fibres in the brain, and into the nervous fibres in the body; to be inserted into all the globules of the blood, and produce the life of the body. The existence of feeding pores and subtly chyliferous fibres or vessels of this kind, is convincingly demonstrated, 1. By those who have continued for months, years, and still longer periods [lustra], without visible and terrestrial food, and whose life has been renewed from day to day with blood (*xx*). 2. To say nothing of various species of living

(*uu*), The corporeal fibres mentioned above do not terminate until they arrive in the cortical substances, where are the first boundaries from which the fibres run forth (n. 507).

(*xx*) Respecting the subjects of adipsia, or those who have abstained from food for long periods of time, see Simon Majolus, Caspar a Reies, Marcellus Donatus, John Schenck, Daniel Sennertus, John Jonston, John Rudolph Camerarius, Quercetanus redivivus [Joseph Duchesne], Martin Schurig, and other writers. [See Part II., p. 188, n. 406 (*k*).] *Christ. Mich. Adolphus relates the case of a Silesian girl

* The cases in note (*xx*) are taken from Martin Schurig, *Chylologia Historico-Medica*, cap. iv., *De Asitia et Adipsia*, p. 175—204; 4to., Dresdæ, 1725. The following, with some correction, are the authorities given in Schurig's work :—

creatures, that live for whole winters, and even for ages

who took no food for nine months.[a] Alexander Benedictus, of a person at Venice who took no food for forty-six days.[b] Johannes Matthæus Hessus mentions several similar cases from other authors; for example, of a native of Almeria who neither eat nor drank for four months: of one Margareta Rhodia who took no sustenance for more than sixteen months: of a young female, a native of Germany, with whom this was the case for two years.[c] Johannes Wier gives an account of Henricus ab Hasselt, who abstained on two occasions for forty days.[d] Paulus Lentulus has published a little treatise respecting one Apollonia Schreiera, who abstained for eighteen years;[e] and Josephus Quercetanus[f] and Gregorius Horstius[g] have also made mention of the same person. Another instance is that of a girl at Spire, Margareta Seyfritia by name, whom Ferdinand, king of the Romans, in 1542, consigned for the purpose of observation to the charge of his own physician and another person, both extremely trustworthy men: and Gerardus Bucoldianus, physician to the king, and a witness difficult to deceive, declares that this girl took no food from 1530 to 1540, and [again] after this, not for three years.[h] Johannes Langius also mentions the case.[i] Guil. Fabricius, Hildanus, gives an account of a girl at Cologne who abstained for three years;[k] and of a girl at Meurs, named Eva von gen End, *alias* Eva Flegen, who abstained for sixteen years.[l] Johannes Wolffius, of a girl living near the town of Commercy, in the district of Toul, with whom this was the case for ten months;[m] and Petrus Gregorius relates that the asitia of this patient lasted for twelve years.[n] Franciscus Citesius relates the case of a girl (Johanna Balam) living at Confolent, who remained without food for fourteen years.[o]

[a] *Ephemerid. Acad. Nat. Curios.*, cent. vii. & viii., obs. 34, p. 81, 82; Norib, 1719.

[b] *De Re Medicâ*, lib. xi., cap. x., p. 204; fol., Basil., 1649.

[c] *Quæstion. Medic.*, quæst. v., p. 26; 12o., Franc., 1503.

[d] *De Comment. Jejun.*, oper., p. 761; 4to., Amstelod., 1660.

[e] *Histor. Admirand. de prodigiosâ Apollon. Schreieræ Inediâ.*

[f] *Diætet. Polyhistor.*, sect. ii., cap. iv., p. 173-175; 8vo., Lips., 1607.

[g] *Instit. Medic.*, disput. iii., op., tom. i., p. 141; also tom. ii., lib. ii., obs. 29, p. 97; and lib. xi., obs. 1, p. 519; fol., Norimb., 1660.

[h] *De Puella quæ sine Cibo et Potu Vitam transigit.*

[i] *Medicin. Epistol.*, lib. ii., epist. xxvii., p. 604; Hanov., 1605.

[k] *Obs. Chirurg.*, cent. ii., obs. 40, p. 116; Opera, Franc., 1646.

[l] *Ibid.*, cent. v., obs. 33, p. 413.

[m] *Lect. Memorabil.*, cent. ix., p. 218; Lauingæ, 1600.

[n] *Syntax. Art. mir.*, tom. i., lib. xxxv., c. x., p. 399; 8vo., Colon., 1610.

[o] *Abstinens Confolentanea.*

[ætates], upon no other than invisible support (*y*). 3. By those airs or breaths by which we are immediately refreshed, exhilarated, and revived; or on the other hand, with equal suddenness, deprived of sensation, thrown into swooning, or killed outright. 4. By sympathetic exhalations, whence love for which we cannot account; or antipathetic exhalations, whence dread (which often runs in families) when certain objects are present, although not perceived by either smelling or sight (*z*). *In part to the pulmonic cells, which are the* [*little*]

See also the account of brother Nicolas, a hermit, who did the like for nineteen years and six months.[p] Of a boy in Brunswick, who lived in this way for four years, as mentioned by Gregorius Horstius.[q] Of a girl at Halberstadt, who lived for ten years without food, [although not without drink,] as stated by Daniel Sennertus.[r] Of a Norwegian girl who abstained for [nearly] a whole year, [only eating and drinking when compelled to do so,] as stated by Caspar Bartholin.[s] Of [one Esther Johanna], a Swedish maid, born in the village of Norre Oby, in Scania [Schonen], who abstained from food for ten years, and from drink for eight, and whose case was carefully watched by many; and is treated of by Joh. Jac. Doebelius,[t] Professor of Medicine in the University of Lund, and by Jesper Swedberg,[u] Doctor of Theology and Bishop of Scara, my beloved father.

(*y*) As is perfectly well known to be the case with vipers and other serpents, with crocodiles, swallows, the chameleon, the ostrich, the balm cricket; nay, even with those most voracious creatures, bears, which entering their winter dens with their cubs, lie through the brumal months without a chance of food, sucking their paws with a constant murmuring sound, and yet meanwhile are not emaciated, but if anything fattened; as shewn by those that have been roused up, and driven from their lurking-places, &c. [See Part II., p. 188, n. 406 *(l)*].

(*z*) As may appear from the antipathy [which some persons have] to different objects of the animal kingdom, as cats, mice, wasps,

p *Philosophia Mystica*, p. 100; 4to., Neustadt, 1618.

q *Opera*, lib. xi., obs. 1, p. 519; fol., Norimb., 1660.

r *Medicina Practica*, lib. iii., part. i., sect. i., cap. ii., p. 385; op., tom. iv.; Lugdun., 1676.

s *Act. Med. et Philos. Hafn.*, vol. i., obs. 139, p. 292, 293; an. 1671, 1672.

t *Historia Inediæ diuturnæ Estheræ.*

u I have not been able to meet with Bishop Swedberg's narrative, but see the *British Magazine*, Sept., 1746, p. 252, 253, where there is a translation of part of a letter from him to the Bishop of Bristol on the subject of Esther Johanna, there called Estrid.—*(Tr.)*

refectories of the blood, and the preparatories that change it from venous to arterial. For in these cells, the blood, (which is squalid, lurid and dark when carried thither from the right chamber of the heart,) by mixture with this aliment, acquires its bloom, beam, and vital flame: for the more largely the blood feeds on this ethereal dessert, the more bright and refulgent is its life; wherefore it passes from these banqueting-rooms of the lungs into the left chamber of the heart, no longer venous as before, but almost arterial (*a*). *In part to the left chamber of the heart,—the starting-place from which the blood comes forth, now a second time fed with celestial food.* For there are three common fountains of life, the brain, the lungs, and the heart: to these, as we said above, the atmospheric world and the terraqueous globe fly with one accord, with their aliments and genial gifts. From these the brain derives its food; the lungs and the heart, theirs; but at stated times. The brain pours forth the spirit and blood that it eliminates therefrom, into the right chamber of the heart; but the lungs pour forth theirs into the left chamber. Thus both guests,—the brain as well as the lungs,—convey their chyle, their spirit, and their blood elaborated therefrom, or to be elaborated, into both chambers of the heart; and there, as in a public and common resort, spread their table: and if anything be wanting, the heart brings it forth out of its own system [præcordia], to which similar feeding fibres run (*b*). Thus every fibre and vessel is provi-

hedgehogs, and to particular men:* or to objects of the vegetable and animal kingdom, as cheese, butter, the flesh of certain birds, fishes—herrings, for instance, berries,† &c. Not to dwell upon those things that proceed from the ground of imagination, having been previously perceived by sight or one of the other senses. And a similar natural abhorrence occurs in all species of animals, not merely when they see the enemies and destroyers of their race, but even when they detect them by the mere force of exhalations.

(*a*) On this subject see Part II., the Chapter on the Lungs, p. 183—191, n. 406; and the *Economy of the Animal Kingdom*, tr. i. n. 50. These vessels do not terminate in the body until they arrive in the pulmonary vesicles. (See above, n. 507, *t*.)

* See Schurig, *Op. Cit.*, cap. iii., *De Nauseâ et Antipathiâ*, p. 155—162. *(Tr.)*
† See *Ibid.*, p. 105—123. *(Tr.)*

sioned and supplied from this cuticular and universal market (*c*): *use and want in this place regulating and dispensing the quantity* [*and quality*] *of this aliment.*

510. II. *But the pores of the second kind, which we have termed ducts, simply expiratory, put to flight and exterminate the injurious and recrementitious matters that infest the purer blood and the spirit, that irritate the interstices of the fibres* [*and of the nervous fascicles*], *and that beset the lesser cutaneous parts* (*d*). The problem of the genesis, origin, and nature of the exhalations that transpire in such abundance through the substance of the papillary cutis, full as it is of clefts and dotted all over with pores,—whether these exhalations proceed from the little arteries, or from the nervous fibres; or from the serous current of the red blood; or from the lymphatic stream of the prior or pellucid blood;—this problem cannot be settled by the eye, by the microscope, or by anatomy; but its solution may be inferred by tracing phenomena and effects to their causes; especially by comparing together the generation and subsistence of the two kinds of blood respectively, the red and the pellucid (*e*). By

(*b*) The heart is not only a mixing vessel and cauldron, but also a chemical organ for preparing liquids to enter the composition of the blood. (*Econ. A. K.*, tr. i., n. 453—457.)

(*c*) By these means it is most wisely ordained, that whatever exists in the world or universe of nature,—whatever is laid up in the great bosom of things,—shall minister and yield compliance to the subjects of the animal kingdom, and preëminently to their blood. (Part II., p. 191, n. 406.)

(*d*) Respecting these pores of the second kind, and their origin, nature, and function, see above, n. 505. At present we are chiefly occupied with the material of their expiration; for if we wish to unfold the use of all things, it is not enough to examine and consider the continent alone, but we must also take equal account of the content, by which means at last both the function and use are displayed before us.

(*e*) There are two kinds of blood, a grosser blood, and a purer blood, and the former is red, the latter transparent. (*Econ. A. K.*, tr. i., chap. I., On the Composition and genuine Essence of the Blood.) For it has been discovered by the practical researches of many anatomists, and of Leeuwenhoek in particular, that the globules of the red blood in the least arterial capillaries suffer themselves to be resolved into pellucid globules; so that nothing runs through the lesser canals of the

this means we understand, that as the blood renowned for its redness is conceived and born from its chyle, and thenceforth is constantly poured around in its vessels; so also the purer blood, still more illustrious for its whiteness, is conceived and born from a chyle of the finest kind, similar to the lymph in the articulated vessels termed lymphatics. The serum of both these kinds of blood requires to be lustrated and cleansed of its impurities and off-scourings (*f*); that of the red blood, by the papillæ, pelvis, and ureters of the kidneys, and all over the surface, by the miliary glands of the cutis; that of the white blood, by similar but smaller forms, disposed in the universal cuticular circumference of the body; and which are the pores at present under consideration, whose spiracles open in the sequestered recesses or furrows of the epidermis. These remarks illustrate the *nature* of this effluvial vapor; but with respect to the *springs* from which the subtle but hurtful lymph is expelled before it is derived into these its little tubes, if we closely consider the follicles, papillæ, vessels, and fibres of this part, three ways are opened to us: the *first*, through the extreme arterial twigs, or

arteries but the purely sanguineous essence, set free by the resolution of the globules of the red blood; wherefore the volume of such [essential] globules cannot be called by any other name than that of the prior, purer, or pellucid blood. But this blood is actually the very lymph that the lymphatic vessels absorb, and carry back through the thoracic duct into the red blood. (Part I., the Chapter on the Glands generally, p. 237, n. 181; and the Chapter on the Thoracic Duct, p. 213, 214, n. 162.) In an absolute sense, indeed, the purer or pellucid blood is the animal spirit, which floats in its lymph, as the red part of the blood floats in its serum: wherefore the former kind of blood, or the spirit, is in like manner beset and surrounded by a serum, but of the most refined and delicate character, and properly termed lymph; for it is prepared and fed in the same manner as the red blood, but on the purest or ethereal aliments, as explained in the preceding paragraph. I am now going to shew, that the recrement of this latter serum, but not of the serum that flows around the globules of the red blood, is the very thing that these pores throw out. For as these sera are perfectly distinct in origin, nature, and function, so also their excretions are not confounded.

(*f*) See just above, note (*e*).

through the ultimate vascular foliage, that proceeding from those twigs, and subdividing and splitting repeatedly, covers round the papillæ like a coat of leaves, and into which injections of wax or spirit are alike unable to penetrate (*g*). The *second*, from the interstices of the fibres collected into bundles within each subcutaneous nerve, which fibres bare themselves in this ultimate station, and put off their coats (*h*). The *third*, from the circumscribed empty spaces surrounding the vessels, threads, plexiform trabecular bands, glands, and bulbs that beset the corium; in which there is a humor, volatile vapor,

(*g*) I endeavored to shew in the Analysis of the Kidneys, (Part I., p. 436—441, n. 288, 289,) that the obsolete and sluggish serum is expunged from the genuine, fluid, and red blood, into lateral branches; and this by processes of circuition; consequently from the arterial vessels into the stamina that constitute the cortical substance of the kidneys, from these into the tubuli Belliniani, and so on, into the pelvis and the ureters. The same plan of discharge is put in practice here, but not from the arterial vessels immediately, but from their little branches split into finer divisions. For in order that the recrementitious portion of the serum of the purer blood may be thrown out, it has to be separated in the first instance from the side of the grosser or red blood, which can only be done by repeated splitting of the ramifications. Thus the mode of discharge for the purer substances is strictly analogous to that adopted on a large scale in the kidneys. The mind will have no possibility of doubting that the arteries are split into offsets of such exceeding fineness, if it well consider those little arterial leaves with which the papilla is surrounded, and which invest this very pore in the shape of a fine membrane. From this principle we deduce, that no serosity but the very finest, and which belongs to the family of the purer blood, is squeezed out through these pores.

(*h*) Not only are the fibres themselves permeable, like little canals, but even their very interstices are the same, particularly those lying between the fascicles of the fibres, as will be shewn by many considerations in the Part on the Cerebrum, and the Chapter on the Arachnoid Membrane, and on the sinuous fissures of the cortical and medullary substances; and in the Part on the Fibre. For where no moisture interflows, one part grows to another; although life consists in the most distinct activity of the parts. In the same places it will be shewn, that the little tunics that surround the fibrillary bundles at last leave them in the extremes, and give the enclosed humor room to escape.

and creeping unguent, that moistens the joints, and smears them over, to prevent them from growing to the adjacent parts (*i*). We know from the nature of this abundant moisture, that such is its source; as, on the other hand, we know from its source that this is its nature: consequently, from the characters of the matter exhaled; 1. As being not simply aqueous, but ammoniacal [volatili salinâ], sulphureous, flamy, phosphoric, unctuous, as from so many signs, we know that it has been either a very thin lymph in the little arteries, or a sluggish humor in the nervous fascicles, or else a soft unction surrounding the corpuscules and bands of the cutis (*k*). We

(*i*) On this subject see Part II., the Chapter on the Thymus Gland, p. 269, 270, n. 433, where the following words occur: "Wherever there are cavities, openings, hollow recesses, or rimose interstices, . . . there must be some humor, volatile vapor, and self-diffusing unguent, that will imbue and besmear the . . . joints. Were there not a constant spring and stream of some unctuous moisture of the kind, the passages would close, the pores would become incapable of perspiring, the adjacent parietes would grow together, and the boundaries between things would be confounded; an indistinct, confused, and indeterminable mass would be the result; the forces of powers, the motions of forces, the actions of motions, and the lives of actions, would fall into chaos or nothingness: the ruin of generals would involve the ruin of singulars; in short, the fate of continuous quantities would also be the fate of discriminated quantities, and *vice versa*." See also *ibid.*, note (*a*).

(*k*) On this subject Boerhaave says: "We may now see what is the material, and what the cause, effect, necessity, and use of this perspirable humor, and that it is primarily designed for maintaining the flexibility and softness of parts, and compensating their losses: in fact, that its main purpose is to enable the nervous papillæ to be and continue moist, lively, apt to be affected by objects, and quick to transmit their impressed effects." (*Inst. Med.*, n. 432.) In order then, agreeably to the assertion of this illustrious man, that the papilla may remain in perfect readiness to assume changes of state, according to every affection of the body, interior and exterior, it is necessary, that both the fibres of which it is constructed, and the little arteries by which it is covered, as well as the vessels upon which it is spread, should constantly throw from them all those hindrances with which they are troubled. For the sake of the common function

know this, 2. From the extreme subtlety of the same matter. 3. From its almost inexhaustible abundance (*l*); as plainly shewn by calculation; by the effluvia smelt by dogs; by the perpetual reappearance of the same matter after it has been washed off (*m*); and by the large extent of the circumference of the body, which is its field. For essences are universal in proportion as they are pure, and in the same proportion are luxuriantly abundant, and subject to nice and unremitting elimination. 4. Also from frictions, scarifications, tremblings, menstrua, tinctures, magisteries, aperitive plasters, blisters, or substances determining to a particular part of the surface, and other similar methods and means, by the application of which, not only the humor stagnated in undue quantity in the skin, but also that collected and condensed in the extreme arterial threads, and even in the nerves besmeared with viscid lymph, is diminished and eradicated. 5. Thus where the ethereal food has made itself an inlet, it has made itself an outlet also; that the one thing might follow close upon the other. But there are not wanting lymphatics and veins, that gather the valuable matters with

and use of the parts mentioned,—to preserve the states of their papillæ and of their sensation,—these three sources of this perspiration through the pores or passages now spoken of, cannot in anywise be separated.

(*l*) Respecting its abundance, Boerhaave says: "Hence its quantity is greater than that of all the other excretions put together. In fact, in the climate of Italy, in a person in the prime of life, who enjoys easy circumstances and takes moderate food, the perspiration which exhales from the external skin, the mouth, and the nares, is equal in weight to five-eighths of the aliment taken into the body" (n. 479).

(*m*) "Several times," says Leeuwenhoek, "I applied a clean piece of glass for a moment to the face; . . . and when I submitted the glass to the microscope, I found it much stained with fat. Afterwards, having cleaned the glass, I wiped . . . the face. . . . Then . . . I again applied the glass to the clean skin. And on again submitting the glass to the microscope, I saw so incredible a quantity of fatty and most minute halitus settled upon it, as scarcely any one can conceive without witnessing. After this, I repeatedly wiped the skin with a perfectly clean towel: . . . and . . . applied the glass to the face. And when I looked at it as before, I again saw the fatty halitus" (n. 478).

their little mouths, lest these too should fly away at the same time, and that restore them to the two kinds of blood (*n*).

511. III. *But the ducts of the third kind, more properly called little canals, in nature and office both excretory and adductory, thus hermaphrodite, purge the arterial blood, the subjacent fat, the muscles, and the integuments of the viscera, that is to say, the peritonæum and the pleura, of their grosser impurities, when the outlet through the other doors provided by nature is not available* (*o*). As the pores of the second kind lustrate and rescue the higher, interior, and more excellent blood that runs through the fibres as its arteries, so these of the third kind lustrate and rescue the lower blood, the proper native of the body, from disorderly, antiquated and worthless matters, which will be of no further moment in the life of the body, and throw them out in the form of sweats. A number of circumstances shew that they thus purify and cleanse, 1. The *blood;* namely, the continuous derivation of those ducts from the miliary glands, their

(*n*) "Upon all the muscles," says Boerhaave, "under the skin, is spread a cellular membrane, furnished with arteries, veins, nerves, lymphatics, and oil-cells." (*Inst. Med.*, n. 416.) The little mouths not only of veins but also of lymphatics, are present and at hand wherever the humors are scattered about; and this, to reabsorb those matters that are kindly to the blood;—the veins, those matters that belong properly to the red blood; the lymphatics, those that belong to the purer blood and to the spirit. (Part I., p. 221, 222, n. 169 (*a*); p. 237—239, n. 181, 182 (*n*); the Chapter on the Kidneys, p. 448, n. 291 (*m*); Part II., p. 176, 177, n. 405.) For it is a matter of scrupulous and incessant care, to prevent humors, distinct in origin and nature, from being confounded in the so diverse and yet so wonderfully connected vessels of this tumultuous kingdom; for the lymphs that belong to the purer blood have a higher sphere, function, and use, than the sera of the grosser blood; wherefore, as the vessels are distinct in the body, so also the pores, which are the means of affording them an inlet and outlet, are distinct in the skin. For the passages that draw off and purify the properly sanguineous serum, proceed from the glands of which we are now to treat.

(*o*) See what we said above (n. 506) respecting the origin, nature, and function of these ducts or little canals.

heads and springs (*p*): the intestinular fabric of the glands (*q*), which are thus enabled, by their flexures and circuitous courses, exactly as in the kidneys, to proscribe and extort from the blood those matters that flow languidly and inertly (*r*): the con-

(*p*) These little canals proceeding towards the surface of the cutis, issue as emissaries from the cutaneous glands. See above, n. 506 (*g*), and compare also what Winslow says of the same glands, n. 475.

(*q*) The vessels weaving the glands are stated by Winslow to be analogous to intestines in their tortuosity and circumvolution. "The late M. Duvernay," says he, "clearly demonstrated to the Royal Academy of Sciences, the structure of some of these cutaneous glands, which appeared like circumvolutions of small intestines, plentifully supplied with capillary vessels" (n. 475). Swammerdam found similar structures in the cancellus, if not in the cutis itself, yet under it when divided, and which likewise had their origin from arteries, and went towards the pyloric orifice of the stomach. From these a conclusion may be formed by analogy respecting other cases. Our Author's description is as follows: "On removing these integuments, we come to a great number of white, glistening filaments, which are put together with beautiful regularity, so as to cover a vast number of little parts, all exquisitely arranged, and in external appearance resembling intestines. By tracing these white filaments to their origin, I saw that they were the blood-vessels. . . . What I at first took for little intestines, were all appendages, sometimes single, and sometimes divided; these were of a tubular structure, and whitish color, and contained a matter separated into dissimilar parts, and condensed into serum and coagulum" (n. 481).

(*r*) Respecting the mode in which the serum of the blood is expurgated in the kidneys by the circumflexion of the arteries, see Part I., p. 437, 438, n. 288, where the process is described in these words: "The red or globular blood, considered separately from the accompanying serum, when driven by a slight impulse, tends to flow, and, where it has an opportunity, actually does flow, in gyres and spiral meanders; for its nature whirls and incites it into forms of the kind. Not so the serum, especially what is rough, uneven, sluggish, inert and gravitating, and lends no assistance of its own to any motive force: when such serum is acted upon, it neither endeavors, nor is able, to run forth in any but straight lines, in the direction of its tangent,—it is dragged unwillingly into every curve that it describes: hence it scrapes and presses heavily against the sides of circumflexed vessels, and flies off

tinuous and plexiform arterial textures that enfold the glands with their knotted ends, so that [the glands] are the bases and supports of their terminations, and their centres of conflux (*s*). And many considerations shew, that they also purify, 2. The *fat;* namely, the close vicinity of the glands to the fat, with which indeed they are mostly in contact (*t*): the connexion and conjunction of the two by the vessels that pass and repass between them; and the fact resting upon ocular evidence, that the fat does flow into similar vessels (*u*); the sweat, which is spoiled and polluted not only with serous and dirty waters, but

through all the foramina and little mouths which open on the walls of the arteries, and through the little tubes proceeding therefrom, still following the direction of the impulse received." See also what was said, Part I., p. 440, 441, n. 289.

(*s*) Respecting the sanguineous plexuses of the cutis, superior and inferior, see the observations cited above from Ruysch and Winslow, n. 497 (*d*), and 505 (*y*).

(*t*) "These granules [the glands]," says Winslow, "are partly imbedded in the substance of the cutis, in little fossulæ, which answer to the same number of little moulds or caps in the adipose substance. Their excretory ducts open on the surface of the skin, sometimes through the papillæ, sometimes on one side of them. . . . The greater part of them are the sources of the sweat, and there are some of them that supply an unctuous and fatty matter, of different density, as in the hairy scalp, on the back, behind the ears, &c." (n. 475). And again: "The matter of the other two cutaneous evacuations, . . . that is to say, the dirt of the skin and the sweat, comes principally from the glands of the skin. Each of these excretions exhibits the greatest differences in different parts of the body; for instance, in the head, the arm-pits, the hands, the feet, &c. The dirt of the skin is a more or less unctuous or fatty humor, which collects insensibly upon the epidermis, where it thickens, and forms a species of varnish." (*Exp. Anat., Hist. gen. des Tegumens*, n. 64, 65.)

(*u*) The observation of Malpighi, to the effect, that [in frogs and birds] he has distinctly seen little drops of oil in the [trunk and] branches of the vena portæ, is sufficiently well known and often repeated. (*Exercit. de Omento, Pinguedine, et Adiposis Ductibus*, p. 42; fol., Londini, 1686.) But respecting the discharge of the fat, see Part I., the Chapter on the Omentum.

also with fatty impurities (x): also the actual necessity, that all decomposed portions of fat should be thrown out, as in the omentum (y). Again we have several proofs that these ducts purge, 3. *The muscles, the peritonæum, and the pleura,* subjacent to these fatty strata; namely, the ever-moist and dripping condition of those tunics; that is, of the muscles, from the copious showers excussed by constant exercise; and of the peritonæum and pleura, from a similar cause, as well as from the perpetual arteries that beset their cellular tissue, and fill it with a deluge of serum (z): the conspicuous ducts proceeding from those coverings, which ducts penetrate the muscles, and run all the way to the adipose membrane (a): moreover, the actual necessity for a universal discharge, when other gates of outlet are not available: lastly, the analogy between the office of these pores, and the office of those of the second kind that expel the unctuous vapors of the cutis itself; which analogy requires, that these of the third kind shall eject the similar but thicker vapors besetting the interstices of the grosser tunics spread underneath the cutis. But since these glands are like jointed hinges, affixed, as we said above, to the arterial doorposts, hence they comparatively seldom throw out the burdens of this blood through their emissary ducts into the air, but more frequently *swallow the matters that have been thrown out or are about to be thrown out, and at stated times, seek out and suck in the purer lymphs, or even the thicker vapors, from the air*

(x) See above, note (t).

(y) See Part I., p. 385, n. 264.

(z) The pleura constantly fills its cellular tissue with humor. (Part II., p. 251, 252, n. 426.) It rejects this humor or serosity either to the skin or to the lungs, to be evaporated, or into the fat to be stored away; or else exposes it to the veins and lymphatics, to be reabsorbed. (Part II., p. 253—257, n. 427 and notes; p. 283, n. 439.) And no portion of humor is extruded from the peritonæum into the cavity of the abdomen (Part I., p. 505—507, n. 325); nor from the pleura into the cavity of the chest. (Part II., p. 282, n. 439.)

(a) The cellular portion of the pleura, according to Winslow, "even penetrates the muscles, and communicates with the cellular substance in their interstices, all the way to the external adipose membrane." (Part II., p. 215, n. 415.)

itself. The origin, nature, mode of action, form and situation of these glands all contribute to teach us, that they are receptacles and storehouses, by means of which everything is supplied to the blood that it can possibly want for its fabrics, whether the desired material be aqueous, or saline, fixed or volatile, or sulphureous,—everything that can either slake the thirst of the blood, or appease its hunger; that can fire, warm, or cool it; or exasperate, pacify, or preserve it. Thus the gland lends itself to all circumstances, and affords whatever is desired; whether it has to collect and procure its commodities and extracts from the atmosphere contiguous to the pores, or from the effluvia already exhaled, thus from without; or from the little mouths and goblets of the arteries, or from the adipose follicles, or from the cellulated interstices of the tunics; or whether it has to take a share in part from the one and in part from the other. Therefore, these glandular granules are located in centres of confluence, and as it were in a common market that has lanes and streets running to it from every quarter, and there build their cottages (*b*). But nothing results from potency alone; there must be an active force ruling by its motion, in order that the gland may live in activity, and actually dispense its gifts. Therefore, of necessity, it is acted upon,

512. IV. *Unintermittingly, by a kind of systolic and diastolic motion, synchronous with the pulsific movements of the heart and arteries; which motion seizes all the cutaneous parts, the little arteries, the papillæ, and the glands, and rouses them to their functions* (*c*): as shewn by, 1. The uninterrupted arterial growth, produced from both the superior and inferior plexuses of the cutis, and in all the threads of which, the heart is as it were

(*b*) We clearly proved in the two preceding Parts, that the aorta supplies whatever quantity and quality of blood the viscera in the extremes desire and demand. (See Part I., p. 337, 338, n. 239; p. 340, n. 240 (*h*); p. 359, n. 248; Part II., p. 245, 246, 247, n. 425; &c.) Hence particularly from these glands, which are resting-places that have so many wayfaring passages leading to them.

(*c*) The viscera require to be excited to their functions, by means of motions; in other words, motion is the only means of educing from fabrics effects answering to their fabric and consequent nature. (Part II., p. 138, n. 392, *a*.)

present with its vibrations. 2. The insertion of the arterial ends in the very glands, as in knots that they themselves tie, or in props by which they support themselves, and receive and sustain the ultimate circles and motions of the heart. 3. The similar arterial networks that wind to form the little canal raised up from the gland, and that surround the papillæ with a kind of softish membranous bark. 4. And the fact, that in the living body, we have nowhere any concretion or growing together of parts, but everlasting dividuation, thus perspirability, mobility, life (*d*). 5. Wherefore these glands, like little hearts, attract and snatch the necessaries of bodily life, from the air, the blood, the fat, and the surrounding cellular markets; and drive them inwards, whithersoever they are wanted for use. The quantity of effect arises from the quantity of motion; no matter whether that effect be reparation or purification; but the provident supply of such things as are either useful or gratifying to the body, arises from the sensitive power that is contained in the fibres; that is to say, from the power they possess of exploring the quality of the given object.

513. V. *But with infinite variety, according to all changes of state arising from sensation and affection, outermost, innermost, and intermediate.* For there are three universal essences, as chiefs, that have the government and edileship in the kingdom or city of the body; namely, the soul, the animal spirit, and

(*d*) The mobility of the glands in their places, and the fact that they enjoy a certain sphere of activity, is also confirmed by the following observation of Winslow: "These granules," says he, "are partly imbedded in the substance of the cutis, in little fossulæ" (n. 475). See above, n. 510 (*h*); and Part II., the Chapter on the Thymus Gland, p. 269, 270, n. 433. For the more one part is in disjunction from another, and the greater the freedom with which it acts in compliance with every intimation of the soul, but with this reservation, that it be bound in the bond of society to perform mutual offices with its neighbors, the more perfect is the state of the fabric made up of those parts. This law is clearly exemplified in embryos, and in the first rudiments of the body, where the fibres, or membranes, tendons, cartilages, and bones, are articulated and divided in the most distinct manner into their parts, but which parts grow together in the course of time, as youth proceeds to old age, and life to death.

the blood. The empire is so divided between this tetrarchate, that the soul administers the supreme sphere; the spirit, the inferior sphere; and the blood, the ultimate or lowest sphere. Thus each has states allotted to it, and subject to its law; the soul, the supreme states, or the states of principles; the spirit, the intermediate, or the states of causes; and the body, the ultimate, or the states of effects (*e*). The action and life of all is based and founded upon mutual conjunction, and upon the authority of the supreme essence or soul.

514. As there are three states, so there are three causes of their change; but each cause is in its turn both external and internal. The *external cause* of the changes of state in the lowest sphere, or in the body, consists in the sensations of touch, taste and smell. The *internal*, in whatever alters the condition of the viscera and organs of the body, and their power and mode of operating; whence diseases, properly the affections of the body (*f*). The *external cause* of the changes of state in the superior sphere, arises proximately from what we hear and see, or from the two external sensations that minister to the imagination, which is the sensitive power of this sphere (*g*). But the

(*e*) Respecting these three spheres in the living body, namely, the spheres of principles, causes, and effects, see the Prologue to the present Part, n. 468. And respecting the existence of three universal essences, that administer the government in the body, see Part I., p. 487—490, n. 313, 314, 315. And indeed we all know that there is such a thing as the blood, as the animal spirit, and as the soul; and this, even from their determinations, the vessels and fibres; and besides this, from their operations, each of which is manifestly distinct from the other.

(*f*) In addition to the above, there are also agreeable affections of the body, which are properly termed pleasures, not arising from external causes or sensations alone, but from internal causes as well. These properly constitute the pleasures of the body. But to avoid obscurity, I have thought it advisable to refer only ailments and diseases to this class; because it is so well known how many changes these induce upon the blood, the vessels, and the fabrics constructed of them. Respecting the affections arising from the sensations of touch, taste, and smell, see the following paragraphs.

(*g*) As each sphere has its own affection, so also it has its own

internal cause arises from the power that this sphere has of turning over the ideas of its memory, and at the same time of stirring them by the afflatus of the superior or rational mind; hence its delights, appetites, desires and sorrows, properly the affections of the animal mind (*h*). But the *external cause* of the changes of state in the supreme sphere, where the rational mind resides, consists in the influence of the animal mind affected as above, which supplies the stimulus to the thinking faculty of the rational mind. The *internal cause* is either from the rational

sensation. The superior or middle sphere, of which we are now speaking, in the matter of sensation, is nearly at one with ocular sight, and its ideas, with the images of the eye; wherefore it is termed interior sight, or imagination. But nevertheless it will be shewn in our Psychology, by many considerations, that imagination, as a sensitive faculty, is distinct from ocular sight, as well as from rational sight, or thought. For ocular sight receives its images proximately from the circumambient visible world; but imagination, from the memory, in which the images of ocular sight are treasured up. Imagination remains even when ocular sight is extinct. And it is likewise distinguished from thought; for imagination is strongest in our boyish years, but thought grows up in adults, and attains its perfection in old age. Imagination is awake in noctambulists, while thought is utterly asleep. Imagination exists even in brutes devoid of reason, but not thought, which is properly human. On this account ideas are divided by philosophers into material and immaterial.

(*h*) The affections of this faculty are principally, either *delights* arising from the harmony of objects; or *longings* for those things that serve to recruit and repair the body, (whence thirst, hunger, and the like); or *desires* for those things that favor the pleasures of the body, of which they are the inciting causes, the fuel, and the fire; or *sorrows*, which may also be termed the sufferings [passiones] of the animal mind. But if it be wished to proceed still more distinctly in the arrangement of causes, they should be distributed into inferior, superior, and proper: the inferior rising into this sphere from the body; the superior falling down into it from the rational mind; but the proper proceeding from the excitation of their own faculty itself upon its imaginative power. And the same occurs in the other spheres; but this is not the place to let the mind go forth into any further details of distinctions than are involved in the subdivision into external and internal.

mind itself, or from the soul, which flows with the light and heat of its life into the sphere of the rational understanding and will; hence either internal joys, or desires, or loves, properly the affections of the rational mind, which respects as ends the varieties of goodness, and particularly of moral goodness.

515. All these affections, from whatever cause arising, alter the connexions, positions, orders, forms, and consequently the essential conditions of things, and the modes in which forces act; thus the linkings and associations of states; but especially do they invade the universal essences. Thus the affections that flow from the body, immediately seize the *blood;* consequently its vessels, the arteries and veins; and if these, then also the viscera constructed by them. Those that flow from the animal mind immediately affect the *spirit of the blood;* consequently its vessels, the nervous fibres, and the organs and sensoria fashioned of them. But those that flow from the rational mind assail the very *soul of the blood and spirits;* consequently, the simplest fibres, or the rays of determination of the fibres; and if these, then also the primitive forms generated by them (*i*). All the changes of state in the animated body issue from these affections as their living springs.

516. Affections in general either inspire life, or threaten death; thus either induce heat and activity, or cold and inertia; and hence we have various changes produced in the vessels or fibres, consequently, in their organic textures; which changes, speaking generally, consist in expansion or constriction, extension or retraction, induration or softening; the effects of which, in the sensorial organs, are either acuteness or dullness; and in the motorial organs, either activity or torpor (*k*).

517. The papillary substance, which mainly constitutes as well as environs the cutis, is so susceptible of change, that at

(*i*) We shall speak of this subject in our Rational Psychology, where any clouds that may now present themselves, by the blessing of God will be dispersed.

(*k*) Among the changes here mentioned, the varieties and differences are infinite; so much so indeed, that it is impossible to classify them distinctly in this place. For which reason I have chosen to touch upon only the most general, and the universal of them.

every slight affection of the body, of the animal mind, and of the rational mind, it either expands or contracts, extends or retracts, or indurates or relaxes; consequently, either sharpens or blunts its sense. Thus it is that this substance opens or shuts the pores, ducts, or little canals that it is conveying either outwards or inwards through its soft or papillary structure, at the very instant that it is itself affected. Hence the infinite variety of the matters perspired, attracted, and discharged: and hence a state of the microcosm very similar to the state of the macrocosm, in that the latter at one time draws up rainy vapors, at another assembles them in clouds and masses, at another dissolves them in showers; at one time is serene and glad, beautiful and bright; at another is beclouded, gloomy and dark; at one time is baking with heat, at another time is shuddering with cold. The difference consists entirely in the number of variations.

518. In order then to explore the conditions of the perspirations, and their alternate changes, we must recur to the causes that affect the sensorial papillæ, generically, specifically, and particularly; consequently to the affections that alter states: but this circus is too extensive to allow us to give our uncaparisoned horses head-way into it from the present starting-place. All that we can say, while we are here tarrying in the entrance or stable, is, That there is a perpetual battle and collision of the spheres with each other; namely, of the blood with the spirits, and of the spirits with the soul: consequently when the blood-vessels are expanded, the spirit-vessels or fibres are closely compressed, and *vice versa* (*l*). Very much the same may be said of

(*l*) "When the sweat is increased," says Boerhaave, "and its vessels enlarged, the perspiration must necessarily be diminished, and its vessels compressed" (n. 479.) The same thing may also be seen from a careful anatomical investigation of the papillary structure of the cutis; for subtle membranes, and as it were meninges composed of the ends of vessels, not only surround the papillæ, which are bundles of fibres or of fibrous villi, but also invest the pores themselves. Hence when the blood is dominant [regnat] in its vessels, the fibres beset and enclosed by those vessels must of necessity be closed; consequently also the pores constructed and made by the fibres. Furthermore, in

the pores, ducts, and little canals, convoluted and beset by those vessels and fibres. From these causes, as well as from others, proceed the innumerable diversities of the perspirations.

519. From all these considerations one thing is perfectly clear, which I wish to present as the conclusion of these hydrostatic enquiries respecting the skin of the body; namely, that the ultimate sphere, or the sphere of the body, subsists and is nourished entirely by aliments taken from the bosom of the earth; but the supreme sphere entirely by ethereal provisions and celestial food, liberally and largely supplied through the exquisitely delicate mouths of the cutis; and the middle sphere, by both (*m*). Hence that the grosser, inferior, and lowlier portion of us is constantly supported and recruited from the earth;

this perpetual conflict of the blood with its spirit, that is, in the action of the blood upon the vessels, and of the spirit upon the fibres, we arrive at the cause of muscular motion. For when the spirit acts, the blood must yield; and when again the blood acts, the spirit yields; and this alternately, according to the determinations commanded by the principles. But of this subject more anon; as well as of the state of the perspirations, as changed in each particular disease of the body, ailment of the animal mind, and affection of the rational mind. But were I to deflect my course in this direction at present, I might soon shed darkness upon the universal ideas just laid down, on account of the infinite varieties occurring in each.

(*m*) From a careful consideration of the perspirability of the papillary cutis; from the luxuriance and apparent infinity of the first kind of pores (treated of above, n. 504, 509); from the stupendous fineness of the fibres that generate our innermost sensorium; and moreover from the unanimous consent of supporting phenomena, we may all conjecture, that the fabrics and forms of the innermost organs, which are in the very cortical substances, cannot by possibility be formed, repaired, or nourished from terrestrial chyle or food. In order that our rational mind, of whose purest [forms], or of the principles of whose sensoria, I am now speaking, may work with, and lay itself out in, its ideas, all elements derived from terrestrial food and the chyle thereof, together with the red blood itself, must rather be put away, and driven from it as from the inmost recess of a sacred temple. Nor is there any organ or laboratory in the body, that can attenuate and digest the chyle into essences so fine and pure. On the strength of these and other considerations, I have no hesitation in concluding, that

but our purer, superior, and more excellent part, from heaven, although so long as it is in connexion with the body, it is not aware of the high food on which it feeds.

520. VI. *By an attentive review of the above positions, a knowledge of many of nature's secrets is brought to the light of our understanding, although still in only an obscure manner; for instance, we understand in this way, the derivation, production, and generation, in living bodies, of the inferior and ultimate universal essence from the superior and supreme.* Inasmuch as there are three universal essences in the body, the soul, the animal spirit, and the blood, and the same number of determinations, or fibres and vessels, it follows from the foregoing series of analyses, that from the supreme essence is derived a proximately inferior essence; and the latter determining, a kind of new principle is formed, which may be called the corporeal or material principle; in which, by the influx of the inferior essence just spoken of, a still inferior essence is conceived and born, the last or lowest of the three. By means of this again the whole body with its members and parts is built and formed. And when this gyre of formation is accomplished, then the lowest or last universal essence passes to the supreme universal essence, and enters into intimate and absolute union with it; and thus the inferior or middle universal essence, which is termed the spirit, proceeds from both (*n*).

while we live in the body, our innermost forms are nourished by celestial, but our outermost or corporeal by terrestrial, food. But I shall pursue this subject further in another place.

(*n*) The proof of this theorem was promised in Part I., p. 489—491, n. 315, where it is stated in nearly the same words. In the passage alluded to, it was indeed illustrated in some measure by the notes or commentary; but since I had not then treated of the skin, nor of the origin of the corporeal fibres and of the blood-vessels, I had no choice left but to refer for proof of these points to this part of my investigations. Wherefore, to keep my promise, I will, while occupied in examining and unravelling the skin, draw the analytic thread hither, as to a purposed end; although the last touch, or the finishing stroke is still wanting, and can only be given in the Part on the Cerebrum. Meantime, first consult what we said in the passage above cited. For *there are three universal essences, and the same number of determina-*

TOUCH.

521. *Touch expresses and represents the other senses as it were in a grand type, particularly taste and smell; for these senses agree with touch in their fibres or papillæ.* Thus the tongue, or the common organ of taste, is furnished and beset on its apex, dorsum, and prominent parts, with papillæ similar [to those of the skin]: its papillæ also, like those of the skin, appear pyramidal and conical (*o*), and when in contact with

tions. (n. 513, and Part I., p. 487—489, n. 313, 314.) *From the supreme essence is derived a proximately inferior essence;* that is to say, from the soul, the animal spirit, which is the medium by which the soul flows into the blood (n. 509). *And the latter determining, a kind of new principle is formed, which may be called the corporeal principle;* namely, the corporeal fibre, and from it, the arterial vessel (n. 504, 505). *In which, by the influx of the inferior essence just spoken of, a still inferior essence is conceived and born, the last or lowest of the three:* in short, the red blood in the artery, by the influx of the animal spirit (n. 504 (*p*), 509). *By means of this again the whole body with its members and parts is built and formed;* to wit, by means of the blood and its vessels, all the viscera and organs of the body. *And when this gyre of formation is accomplished, then the lowest or last universal essence passes to the supreme universal essence, and enters into intimate and absolute union with it* (n. 507). In other words, the blood-vessel does not cease except where the innermost coat of the arteries places its boundaries, consequently the last boundaries where the fibres place their first; namely, in the cortical glands of the brain, where the soul resides in its principles, and as it were in its Olympus and heaven, and where the laboratories of the spirits are situated; whence the spirit sent forth by both through its fibres into the universal body, attends at once to the offices of both.

(*o*) Respecting the papillæ of the cutis, Heister says, that they are "for the most part pyramidal in shape, and reaching forth through the Malpighian rete to the cuticle . . . constitute the primary organ of touch" (n. 472). They are also delineated as such by Ruysch (*Epist.* i., tab. i., fig, 5, 7), and Bidloo (*Anat.*, tab. iv., fig. 6), and described by Malpighi in these words: "Inasmuch as the pyramidal papillæ proceed from a comparatively broad base to a kind of point, before they are

demulcent, bland and soothing objects, extend and open out, so as softly to embrace with their whole bosom the things presented to them: but when in contact with anything rough or pricking, they, like the papillæ of the skin, draw back into the woof of their nerve, and harden and bristle up (*p*). The lingual papilla, like the papilla of the skin, is discriminated from its fellows, and confined in its place, by a reticular substance; and overlaid by a vaginal covering, not squamous indeed, yet borrowed from the external cuticle (*q*). The organ of smell again is not dissimilar to the gustatory organ of the tongue, or to the tactorial organ of the skin; only its papillæ are smaller, and in the dead subject lie hidden under a fine membranous clothing (*r*).

expanded into the cuticle, hence they are not of one and the same figure at their sides." * The next chapter will, in fact, be the proper place to speak of the papillæ of the tongue, and their similarity to the papillæ of the cutis; but lest the mind in the meantime should come to a stand still amid unexplained assertions, and be in doubt and obscurity, I will at any rate transfer hither from its place Heister's description of the papillæ of the tongue. "The third [membrane of the tongue]," says he, "or membrana papillaris nervosa, . . . contains nervous papillæ of different shapes, but chiefly fungiform; . . . also pyramidal papillæ large and small." (Part I., p. 18, n. 25.)

(*p*) See above, n. 516.

(*q*) "It [the corpus reticulare]," says Heister, "is also seen on the tongue, and indeed much more plainly and distinctly than elsewhere; and the tongue, therefore, is the part in which its nature and constitution may be most successfully investigated" (n. 471). And in another place he says: "Both these kinds of papillæ [the large and the small] arise from the internal membrane of the tongue, and from its nerves; they pass through the little foramina in the reticular membrane, and terminate in the vaginulæ of the external membrane." (Part I., p. 18, n. 25.)

(*r*) "In these places especially," says Winslow, [alluding to the parietes of the septum narium, &c.,] "we . . . discover a fine villous substance; but it is not seen unless the parts be examined in clear

* This passage does not occur in Malpighi's Epistolary Dissertation, *De Externo Tactus Organo*, nor have I been able to find it in any part of his works. The context seems to be required to make the latter portion of it intelligible.—(*Tr.*)

522. *And taste and smell, like touch, are excited by corpuscules endowed with* vis inertiæ, *that stamp a figure of themselves upon the little papillary forms.* For the food taken, sipped, and tasted by the tongue, consists of none but dead parts, derived from one or another of the earth's kingdoms; and moistened with the salivary menstruum, or with any liquid menstruum that has been drank, so as to float dispersedly and freely, and by virtue of the stream or motion assisted by the living heat, to turn their sides and angles to the papillæ, and imprint upon them, as forms, a type and image of themselves. So likewise the parts that strike the organ of smell; these, which are more minute, and are evaporated from the same kingdoms as effluvial exhalations, flit still more freely in the air and ether: nevertheless they are of the family, because from the kingdoms, of heavy and inert things, which have no inherent activity implanted in their form to serve as their ground of action (*s*).

523. *The case is different with sight and hearing, the organs of which are accommodated to the modification of the auras, and therefore do not receive the impulses of inert forces, but the forms of active forces,* and having received them, conduct them by the nerves to the supreme chamber of the sensoria, that is, to the cerebrum. For the ear is constructed on the principle of modified air, or of air acting from modification, of tympana, fenestræ, tubes, cochleæ: the eye is constructed on the pattern of modified ether, of tunics, as the cornea, alluginea and

water, in the manner which I have used . . . for above twenty years past." (Part II., p. 6, n. 340.)

(*s*) I shall have to treat of these subjects in my Analyses of the Senses of Taste and Smell; and indeed I do not know that any one ought to entertain a doubt, that the corpuscules set free by the division and solution of the food are of an inert nature, similar to that of the bodies of the vegetable kingdom, which grow from the mineral kingdom; and to that of the bodies of the animal kingdom, which come from both the vegetable and the mineral. For the earth is the repository of all inert parts. The same remarks apply to the exhalations that are evaporated so abundantly from those kingdoms, and float about in the air. For these are what strike the organ of smell: by this sense also they manifest their peculiar nature; and shew that they are of the same class as those that affect the sensorium of taste.

sclerotica, and of humors, as the aqueous, vitreous, and crystalline. Thus everything is modelled to the forces acting upon it; and thereby the organ itself declares the character of its acting principle, and *vice versâ*, the acting principle, the character of its organ; for the one receives the impression, the other gives it; so that it is impossible that the seeing mind should not be instructed by the one respecting the other. The modificatory rays keep their line, urge their way, carry out the force that they have received, thus strike impulsively upon the objects that they meet; so that *impulse* may fitly be predicated of them: but corpuscules of an inert character, driven to the centre to which the active forces unanimously tend, fall whither they are carried, there press or are incumbent by their gravity, and by virtue of the motion communicated to them, both urge and act (*t*), and thus impel; so that *impulse* may fitly be predicated of them also. But inasmuch as these corpuscules are variously figured, and apply projections, points and angles, or plane, convex, or concave surfaces, to the papillæ, so they properly touch those things that come in their way. But the question whether *touch*, as a common formula, answers to both forces, and thus to every one of the senses, is a piece of scholasticism, or rather of trifling, which entangles things in words, when we ought to be disentangling them.

524. *Nevertheless these senses,* [*namely, touch, taste, and smell,*] *are different from each other in nature and character; this being proved by the origin, degree, effect and use of each, as well as by the evidence of our own feelings.* For although touch is associated with taste and smell in the organs of the latter, as will be shewn presently, yet is there no small difference between touch and taste, and between touch and smell;

(*t*) In so far as they are incumbent by their gravity, they urge; but in so far as they are carried by force of motion, which force is active, they act; for from celerity they acquire a certain increased degree of weight: whence it appears, that active or locomotive force is the principle or cause of gravity in those bodies in which activity is either altogether or in part wanting or extinct, and which do not admit of being moved out of their places, unless they are acted upon either mediately or immediately by living forces.

they are in fact so widely distinct as never to approximate save in absolute obscurity, when one or the other vanishes away; and even then they do not really approach, but appear confounded. For they do not spring from the same stock, or from a fibre of the same nature, degree, and composition; whence they cannot be consociated by any bond, because not in their first conditions, and they cannot lead a kindred life (*u*).

525. *As well as from the circumstance, that touch is present distinctly in the organs of all the other senses, and governs in a general manner as it were with them as companions.* As in the eye, particularly in the tunica conjunctiva or adnata, and in the cornea, which defends the pupil: in the ear, all the way to the membrana tympani: in the tongue, from the apex to the dorsum and the os hyoides: in the nares, to the turbinated bones, and here touch is so exquisite and acute, that the irritation arising from snuff, sal volatile, or rays of light, carries off the whole organ with the parts continuously following it, into a spasmodic sneeze. We may easily convince ourselves that touch prevails in these sensoria also, by making trial either with our nails, or with a needle, a probe, or a sharp knife (*x*).

526. *In touch we have also a type of that sensation by which the viscera are affected in their innermost parts, particularly the viscera of the abdomen, as the œsophagus, the stomach, the intestines, the ureters, the bladder; where similar papillary fibres are seen, which are pressed by tactile objects of a not dissimilar character.** It is a most remarkable circumstance, that the hollow viscera in a continuous series, from the first mouth of the lips down to the very end, are covered with the same papillary down,

(*u*) I intend to treat of this subject under a separate head.

(*x*) It is evident from the origin of touch, that such is its universality, that wherever there is a form constructed organically of fibres and vessels, there touch is present; for instance, in the viscera themselves; although it is not manifested therefrom to our sensorium; so that there is nothing in the universal body but derives its very life from this sense.

* This seems to throw light upon one function of the vibratory cilia that are discovered in the internal parietes of so many of the cavities.—(*Tr.*)

or silky villosity as it is called, as the prolabia themselves, and as the tongue, which is prefixed to those viscera, and sits in the rostrum or pulpit thereof. I am now alluding to the œsophagus, the stomach, and the small and large intestines: and not only is it the case with these viscera, but also with the liver, in its glandular follicles, which a second time digests, filters, and washes the portion of chyle received from the above viscera; lastly, with even those viscera that carry down the liquid excrements, I mean the ureters and the bladder (*y*). And corpus-

(*y*) That the above viscera are invested intimately with a kind of papillary or villous coat, see Part I., where we treated of them. But in order that no point may be wanting for the illustration of the present subject, I will subjoin a running statement of experimental proofs. With respect to the *œsophagus*, Heister says: "The fifth [or innermost] coat is villous, and is usually called the crusta villosa: it is covered with a lubricous humor." (Part I., p. 87, n. 73.) And according to Winslow: "The fourth or innermost coat resembles that of the intestines, except that instead of villi it has very small and short papillæ." (Part I., p. 91, n. 76.) With respect to the *stomach*, we are all now aware that it is villous internally. "The fifth [or innermost] coat [of the stomach]," says Heister, "is villous. . . . Malpighi denies the existence of the villous coat: . . . at the same time he admits that there are villi and papillæ in the stomach. . . . Ruysch and Santorinus have shewn us, that they may be made visible in the human stomach by macerating it in warm water; and they are still more obvious in the stomachs of sheep, pigs, dogs, and other animals; so that I have no longer any doubt respecting them." (Part I., p. 110, n. 87.) The stomach possesses most exquisite sense, which is conveyed by the fibres of the par vagum and intercostal nerve to the cerebellum, but not to the cerebrum, and consequently not to the mental consciousness. (Part I., p. 138, 139, n. 106.) For which reason I have occasionally termed those fibres springing from the medulla cerebelli, fibres of nature, but those springing from the cerebrum, fibres of the will. And respecting the similar villosity of the innermost coat of the *intestines*, Heister says: "It [the innermost coat] has on it fine thin villi, resembling the pile of velvet. . . . Ruysch has noticed the same villi." (Part I., p. 143, n. 109.) Winslow declares that this is also the case in the *ureters*: "[Their] innermost coat . . ." says he, "is slightly granulated like shorn velvet, and moistened all over by a mucilaginous liquor." (Part I., p. 420, n. 281.) And in the *urinary bladder*: "[Its] nervous [or in-

cules of the same kind as affect the tongue with touch or taste, above, in the threshold of the viscera, that is to say, in the mouth, also go to affect these succeeding cavities with a similar sense (z). Again these cavities in like manner direct and apply their little villous sensoria to those corpuscules that have passed down to them; and by their vermicular creeping, as the tongue by its rolling and folding, they suffer no part to pass them, without taking a complete account of it, and exploring it by continued touch. Nay, that they search the little fragments offered to them, with some unknown power of feeling, is evident from various symptoms; for instance, from sudden changes, recoveries of strength, longings, loathings, unnatural appetites; from anxieties, windy gripings, heartburn, nausea, headaches, fainting, &c., arising from the presence in the stomach of incongruous food; bitter, styptic, emetic, or virulent drugs; and particularly of worms, such as ascarides, tæniæ, &c., that twitch and gnaw the internal coats of the above viscera, and the tender villosity of those coats.

527. *But since the papillary forms of these viscera do not depend upon fibres originating in the cerebrum, but upon fibres originating in the cerebellum, hence the touches in them do not reach the consciousness of the general sensorium, that is, of our innermost sensorium.* The cerebrum and cerebellum not only dwell under distinct septa and tents, and live without familiar intercourse, within the bony walls of the skull; but they have their separate provinces beyond these boundary walls in the body also, whither they put forth their fibres. The cerebrum, or

nermost] coat, . . ." says he, "is [villous, or] nearly of the same structure as the nervous coat of the stomach." (Part I., p. 458, n. 297.) And therefore the urine, if unusually acrid, excites the whole bladder to spasm, or to a species of convulsive motion. (Part. i., p. 475, n. 304, *a*.) And indeed the above structure exists not only in these viscera, but everywhere else; for instance, in the innermost glands of the *liver*, which according to Winslow "are of a pulpy texture, like radiated villi, with a small hollow in the centre of each." (Part I., p. 259, n. 194.)

(z) That is to say, the parts of the food that in their division and solution have excited the papillæ of the tongue, having now passed down through the pharynx, go to excite the stomach, &c.

the fibre of the cerebrum, occupies the very ultimate boundaries, or the muscular and sensorial circumference of this kingdom (*a*): but the fibre of the cerebellum has for its lot the whole interior field circumscribed by these boundaries, where the viscera of the thorax and abdomen live. The fibre, propagated as an offspring by derivation from its parent cerebrum or cerebellum, when sent out to its goals, and determined to uses in the extremes, carries with it only that character, breathes only that power, and exercises only that force, which it has obtained from its parent; thus the fibre sent from the cerebrum involves whatever the mind of the cerebrum appoints to be executed in ultimates as a matter of choice and will; but the fibre from the cerebellum involves whatever its mind or soul deems advisable to be done as a matter of nature (*b*). The

(*a*) It is very apparent from the sense of the papillary substance, and from the motion of the muscles of the thorax and abdomen, that the fibre of the cerebrum has possession of the cutaneous circumference, both the organic circumference of touch, and the muscular circumference subjacent to the fat of the cutis: to say nothing of the sensoria of the head, as the eye, the ear, the tongue, the nares, or of the muscles of the face; all of which are under the auspices and direction of the understanding and will, consequently of the cerebrum. But the muscular fibres and tunics that invest the stomach, the intestines, the bladder, and many of the viscera or cavities, cannot be excited at pleasure, nor do the touches coming from their papillæ reach even our obscure perception. Thus whatever is at the circumference is subject to the jurisdiction of the ruling cerebrum. This is shewn by the initiaments of the chick in the egg; for the first thing that appears is the cerebrum, with a carina or vesicle, which as a surface encloses the future viscera; shortly afterwards the cerebellum springs up, and from it, the viscera enclosed in the above surface: as we are taught by that sagacious observer, Malpighi, and by other anatomists. See my *Economy of the Animal Kingdom*, n. 242.

(*b*) The fibres bring with them the nature of their parents from the natal soil; the fibres of the will from the cerebrum, and the fibres of nature from the cerebellum. (Part I., p. 50, 51, n. 43 (*cc*); Part II., p. 108, n. 380, *b*.) There is a likeness of the brain in every fibre, as there is a likeness of the heart in every blood-vessel. (*Econ. A. K.*, tr. i., n. 570.) In short, the fibres bring with them the animus of their

former takes the reasons of its choice or will from the sensoria disposed in the boundary of the kingdom; the latter, the reasons of its administration, from the papillæ set within the viscera. In this way we see that the kingdom is divided between the cerebrum and cerebellum, or between the will and nature; and this, in such wise, that nature, which manages the domestic, intimate, and secret affairs of the kingdom, is environed and beset by the will, which attends to the external business that is common to the body with the surrounding world: to the end, that the one may flow wonderfully into the other as it were in gyres, and flow back or turn as it were on hinges. Wherefore as soon as ever the objects of touch have gone inwards, (for instance, from the surface of the body towards the peritonæum and the pleura, from the tongue into the pharynx and œsophagus, or from the nares into the larynx and trachea,) they instantly escape us, and are rolled down as it were into dark ignorance, and manifest their qualities to the consciousness of the soul only, and to its auspices alone submit themselves. For there are two grand pairs of nerves, namely, the eighth or par vagum, and the intercostal or great sympathetic, which succeed and come on exactly at the places where the motorial and sensorial fibres of the cerebrum cease (*c*).

brain, and pour forth and manifest it in extremes; consequently, longing, loathing, and other states may be predicated of them, just as of the animus that arises from the view of things taken by the cerebrum. (Part I., p. 206, 207, n. 156, (*h*, *i*, *k*); p. 207, 208, n. 157 (*l*); p. 222, 223, n. 170, *c*.)

(*c*) It appears from works on the nervous system, that as soon as the par vagum or eighth pair of nerves passes out of the cranium in company with the spinal accessory to the jugular fossa, it runs direct to the pharynx and œsophagus, and this, in order that it may be at hand to receive the materials eaten and swallowed, and that have been driven down and moved on thus far by the voluntary action of the tongue, and to transfer them into the natural motions; and the trunk itself on this account descends along the œsophagus to the stomach, and produces the coronary plexus of the latter. But on this subject see Part I., p. 138, 139, n. 106, (*h*, *i*, *k*). The same nerve, after descending for some distance, reflects a branch that mounts along the

These nerves by their fibres construct the viscera of the abdomen, the well-frequented kitchens of the body, and generate the little papillary or villous sensoria projecting from their innermost coats. It is evident that they are nerves of the cerebellum or nature, and not of the cerebrum or the will; for of this we are assured, not only by tracing them to their origin, but also by the character and properties that they bring with them from their parent's house; in that they are insensitive, administer the innermost things, and do not live in the light of our senses; but withdraw whatever they do from our general sensorium; and communicate nothing beyond some silent effect, by means of their connexion with the neighboring fibres of the cerebrum, or afterwards some ultimate effect, to any of its organs (*d*).

528. *For our general sensorium is laid in the cerebrum, which feels; but the organ of the body acts the part of an instrument only. The cerebrum manifests to us whatever it feels and perceives*

trachea, and is therefore termed the recurrent nerve: this in like manner takes up all the functions commenced in the nares and in the organ of smell, and conveys them down to the lungs; and also takes up the functions of the lungs,—as of producing sounds, throwing out the air,—and conveys them to the palate and the nares. Thus it meets the nerves of the cerebrum or the will in the ultimate boundaries of its sphere, and takes up and continues the offices to the ultimate boundaries of its own sphere, or to the places where it again meets the sphere of the will, or its fibres; as in the lungs, since they have also a voluntary respiration; in the rectum, and in the bladder. But see Part II., p. 108, 109, n. 380 (*b*); and my *Econ. A. K.*, tr. i., n. 495, 496.

(*d*) See the description of the par vagum in my *Econ. A. K.*, tr. i., n. 487, 488. Its use. (*Ibid.*, n. 489.) It arises from the cerebellum. (*Ibid.*, n. 490.) Likewise the great intercostal [or great sympathetic] nerve. (*Ibid.*, n. 485, 559.) The par vagum brings off as many fascicles or bundles as it is about to form plexuses. (*Ibid.*, n. 491, 493.) It requires to be associated with the great intercostal nerve. (*Ibid.*, n. 484, 486, 492, 493.) It reduces subaltern motions to a universal motion, and both these nerves are in the stream of the motion of the brains. (*Ibid.*, n. 483, 491, 493, 494, 496.) We have also the authority of the ancients to prove, that this nerve cannot spring from any soil but the cerebellum.

from the organs of the body: but not the cerebellum. The nerve or fibre upon which the papillary forms or fibres depend, is a clear sensible proof that they do not feel of or by themselves: for when the nerve is either tied or divided, the papilla instantly loses its feeling, and becomes completely insensible, just as though it were excised from the body; if only a single fibre is treated in this manner, one or two papillæ suffer; if the branch of a nerve, then this is the case with a larger number of papillary forms; if the trunk, then with some entire series; if the spinal marrow, with some region or tract; if the corpora striata, then the whole kingdom of the papillary sensorium is affected; and in like manner when the injury is done to the cerebrum itself. There is a connected chain of all things, from the last sphere to the first, and from the first to the last. These points are so certain and familiar, that they are considered as among the first lessons of the art, or the rudiments of anatomical science. Again the same truth comes almost momentarily to the day and light of our understanding; for at one time we ourselves heighten the acumen of the senses, at another time we diminish it, according as we are either present to them by attention and wakefulness of mind, or as we withdraw ourselves from them, and as it were outlie them; whence states of attention or distraction. Wherefore it is not the part of any organ or fabric in the body, to feel, but only to deliver the mutations and impressions received from objects, to a higher feeler, which resides in the innermost recess or supreme citadel of the sensoria. We need no remote indications to tell us, that this hall or senate house is in the cerebrum, and not in the cerebellum; for the fact is too abundantly shewn by proximate evidences. Thus the senses have suffered, and undergone changes, every time their cerebrum was affected; for instance, when it was inflamed, or suffocated with thick blood, or inundated with humor either between the membranes, or between the cortical convolutions, or between the medullary folds, or in the ventricles; as has appeared in cerebra killed by any convulsive disease,—as in epilepsy, apoplexy, phrenitis, loss of reason; for in such cases examination has shewn either displacement, distortion, or contraction of parts of the cerebrum; or purulent collections therein, or extravasation, schirrus, abscesses,

erysipelas, or excavation (*e*). The same thing has been plainly discovered in cases of trepanning, and when the cerebrum has been denuded of portions of the skull; nay, it has been demonstrated to sight by experiments upon living dogs; for when their cerebra have been touched, punctured, or torn, have we not seen contractions, spasms, and tetanic convulsions of the limbs of the body, and have we not heard the dreadful complaints, yells, and anguish of the subjects under operation? Thus we have this truth before our eyes and hold it in our hands. The very fabric of the cerebrum, and our analytic evolution of that fabric, will illustrate and confirm it still further in the Part immediately following. But if we wish to discover where this sensorium is to be found in the cerebrum, we must trace and follow the fibre all the way to its ultimate boundary; thus we must pass through the medullary cerebrum, and not stop until we arrive at the ends or beginnings of its fibres. Here we meet with the principles of the sensation possessed by the fibres, namely, with the cortical glands, where our mind acts from the principles of all the determinations, because from the principles of all the fibres; and whither it collects the light and rays of all its senses, and where it sends them forth into the spacious and interior circus of perception and understanding (*f*). Here our common sensorium is laid,

(*e*) The reader will find a collection of cases of this kind in the next Part, where we shall treat of the Cerebrum.

(*f*) These positions have already been elucidated by experimental proofs in a particular essay on the Cortical Substance, in my *Economy of the Animal Kingdom*. Thus it was shewn that the cortex is the principal substance of the brain, placed in the first boundary of the fibres and in the last boundary of the arteries. (*Econ. A. K.*, tr. ii., n. 110, 111.) And that from a distinct perception of the coördination of these substances, we understand how the will is determined into action by the cerebrum, how by the cerebellum, and how by the medulla oblongata and medulla spinalis; how also in different animals. (*Ibid.*, n. 159—164.) These principal parts of the cerebrum are the organs of the interior senses, and are cerebellula. (*Ibid.*, n. 191—195.) The ultimate reception of modes takes place in the cortex cerebri, which is rendered conscious of all mutations happening in compound series and substances. (*Ibid.*, tr. i., n. 609, and *passim.*) But since these sub-

as well as that inmost sensorium, or intellectorium, which perceives from its senses, thinks from perceptions, judges from thoughts, chooses from judgments, desires from the objects chosen, and finally from the objects desired, determines those that it wills, and thus brings forth by the motoria or muscles the things that it has conceived by the sensoria. And it has been placed in the light of the same experience, that these cortical substances or glands are the complements of the sensoria of the body, or taken collectively, are the common sensorium of all (*g*); for when those substances are affected, the whole appendage of fibres, that is to say, the cerebrum and the body, are affected and suffer at the same time: indeed exactly according to the degree and mode in which they are affected, the forces of imagination are blunted, those of thought languish, the memory fails, the determinations of the will are embarrassed, the desires vacillate, and the sensations are benumbed.

529. *Touch is commonly excited by contiguous objects that strain the connexion of the parts, and especially of the fibres, in the organic body; or influence their position, order, and series, and thus change and invert their states, properties, and functions.* The body in its whole compass and details, is organic, a machine constructed of living wheels, rundles, and cylinders; and these severally made up of fibres, vessels, and all kinds of stamina and textures, in so stupendous a manner, that nowhere is there a fixed point, or a flowing line, where there is not what circu-

stances constitute the supreme sphere of our living system, (see the Prologue to this Part, n. 468,) therefore I have made up my mind to treat further of them after I have spoken of the cerebrum.

(*g*) But we may be deceived by appearances, namely, by the circumstance, that the same effects result to the higher sphere of sensations, although the medullary substance of the cerebrum, or even either of its membranes, and not the cortical substance, be injured; but this proceeds from the same cause as the loss of sensation in external organs when the nerves are wounded or cut; for whatever damage is done to the fibres is done to their principles also; and if they be entirely cut off, communication is instantly lost. Again, the nexus of these substances is disturbed if the pia mater or dura mater be torn from their places.

lates, what breathes, and what acts (*h*). The spirit *circulates* continually through the fibres, even through the innermost

(*h*) For there is a perpetual circulation, not only of the blood through the vessels, but also of the spirit through the fibres; nay, furthermore, a universal circulation, which I have elsewhere called the circle of life; namely, a circulation of the spirit from the fibres into the vessels, and of the blood from the vessels into the fibres. The circle of the blood through the vessels, runs from the heart to the arteries, from the arteries to the veins, and from the veins back to the heart: but this circle is not disturbed when the vessels are touched, in the same manner as is the circle of the spirits when the fibres are touched; because the vessels have innumerable anastomoses, so that if the blood cannot get out through one branch, it escapes through another; and thus the heart, which is the head and beginning of the arteries and veins, suffers no change. But the case is different with the nervous fibre that carries the spirit; this fibre, continued from its origin in the cerebrum or cerebellum, depends entirely upon its parent cortical gland: wherefore if the fibre is touched, or in any way straitened, the spirit has no opportunity of escaping, like the blood, through anastomoses, in another direction. Hence, the instant it is compressed, its principle cannot but feel the change arising from the touch: this necessarily follows, if we grant a continuation through the fibre, as we shall shew that we must do, by a great number of considerations in another place. But the blood-vessel does not feel of itself, but from the fibre, of which its membranes are in part composed; although even this by reflexion; for if the blood-vessel be forcibly pressed, the pressure extends to its fibres also, which enables the vessel to feel, although very obtusely. This regards the first particular; namely, that nowhere is there a fixed point, or a flowing line, in the organic body, where there is not what *circulates*. But with regard to the second; everything *breathes*, that is to say, expands and contracts alternately, and as it were oscillates, in the little cell or seat that nature has assigned to it: for the animation of the brain and the respiration of the lungs rule universally, so that any part that is destitute of their motion or modification, is not a part of the kingdom. (Part II., p. 150, 151, n. 395, *o.*) Evidently in order that all the parts, fibres, and vessels, may be kept distinct from each other, and thus be prevented from growing together, and losing the life and activity that they receive from circulation, and thereby perishing: also that everything may be roused to its work and function. With respect to the third point, that there is nothing that does not *act:* action arises from the conjunction of circula-

fibres; the blood, through the vessels; and the humor conceived and born of both, through the other stamina. Each several thing *breathes*, animates, and undergoes expansion and constriction, in its centre, radius, and circumference. It also *acts*, and moves from place to place; so that there is nothing but may live in acting and act in living; for whatever lives, is acted upon even in its extremes by its principle; and whatever is acted upon, lives even in its extremes, from its principle: wherefore the life in the last sphere represents the life in the first, and a certain presence reigns everywhere. Whatever drives this machine, thus connected, or any part of it, from the place that its order and nature assigns to it, instantly influences and disturbs its *circles;* changes the times of its *breathings;* and clashes with, interrupts, or destroys, the forces of its *actions*. Although this be done in the last sphere, yet is it known and perceived by the life that reigns in the first; that is to say, in the principles, from which come all the fibres, and all the spirit of the fibres (*i*). Hence it is plain, that nothing

tion with respiration; for circulation gives and renews power or potency, respiration or animation infuses force; whence action, which takes place by means of local motion. And in order that there may not only be a natural action of each part in its place by the way of expansion and constriction, which is performed without removing the next part from its place, there is an additional motion proceeding from the will, which motion removes one part from another, although not beyond stated limits: as appears from the action of the muscles, and thereby of the tendons, cartilages, and bones.

(*i*) The cortical gland (n. 528, *f*) either of the cerebrum or cerebellum, is the principle of the fibre; and as there is nothing in the body but is originally constructed of fibres, so there is nothing but depends upon those principles; for the fibres are the determinations of the superior and supreme universal essence. Since then the fibre is incessantly actuated by its principle, the necessary consequence is, that if anything in the middle or in the extremes interrupts the forces of this action, the principle of the fibre feels it, consequently the soul, and our mind, which reside in that principle; for the effect is the continuation of its efficient cause. As soon as the fibre is compressed, the action or animation of the cortical gland must cease, and this, exactly according to the manner, and in the degree, in which the compression exists.

preternatural can happen, either far or near, in the so compound machine, state or republic of the body, without coming to the knowledge of the soul, which from its principles perpetually inspires powers, builds their fabrics, excites effects, and brings forth uses therefrom that correspond to the ends that the soul is incessantly regarding with the eye of the mind. Hence it is also plain, that there is not the least point in any part but a certain sense of touch prevails in it, as a universal informant of events; so that whatever part is devoid of this sense, is no true native of the kingdom, but a mere inhabitant or foreigner, subsequently either to be adopted into the state, or to be cast out of it (*k*). Consequently,

530. *Not only in the papillary cutis, but in every fibrous and vascular texture whatever, particularly in the periostea, the perichondria, the dura and the pia mater, the part under the nails: therefore also in the sensorial organs, as in the tongue, the nares, the ear, and the eye, as we observed before:* or where the fibres are so entwined with the vessels, and the vessels with the fibres, and so inserted into, and connected with, the pores of the little bones, that the one can with difficulty yield to the other; wherefore anything that touches, more manifestly violates the connexion, form, and order of parts in these situations, and endangers, tears, destroys, or tends to destroy (*l*). And then the mind bewails the injury to her fibre, as though it had happened to herself, and grieves for it with heart and soul.

This is the cause of sensation, which exists essentially nowhere but in the soul itself. But we shall treat of this subject more fully in the sequel.

(*k*) This is very manifest from those parts that have their connexion with their associates disturbed either by accident or disease, and which are recalled to that connexion in a thousand ways; or should this be impossible, are dissociated and expelled, lest they should draw sound parts into danger with them.

(*l*) The truth of this proposition is plain from the mere general description of the periostea; respecting which, Winslow says: "The periosteum, in general, is a membrane, or membranous expansion, . . . of a very close and unyielding texture, and exquisitely sensitive, composed of several planes of particular fibres, differently disposed, and intermixed with a quantity of little vessels and nervous filaments. . . .

531. *In order to the existence of a sensorium that can apprehend the several varieties of an object with their differences and distinctions, the fibres must be disposed into an organic form. For the fibres are put together and the form conceived with reference to every kind of variety and idea of use; as the papillary form with reference to touch.* Use has all sway in the body and its organs, and as it were draws the first and last line everywhere, and conceives and builds the fabric on the model of itself (*m*).

The innermost plane of the fibrous texture of the periosteum, which is immediately adherent to the surface of the bone, is fixed thereto by innumerable fine fibrous extremities, detached from all the planes, and implanted in the pores of the bone. Those extremities are accompanied by capillary vessels and nervous filaments, which run some way between the different planes of the periosteum, and penetrate the innermost plane at the orifices of the pores of the bone." (*Exp. Anat., Tr. des Os Frais,* n. 60, 62.) The nature of the connexions of the dura and pia mater will be shewn in the following Part. Touch exists even in the organs of the other senses (n. 525).

(*m*) I endeavored to shew this by an abundance of evidence in the two preceding Parts, in the analysis of each viscus. Thus we have the following positions: Use is the first point of enquiry; since all things are formed according to use: and from the use we know what a member is in itself; what it is in relation to other members continuous with it; and what it is in relation to those prior and posterior to it. (Part I., p. 33, n. 32.) The use, as the end, first of all manifests itself, inasmuch as it is continually present and involved in the series of progression. (*Ibid.*, p. 34, n. 32, *d.*) We are to judge of the fabric from the use: but if the use is unknown, it must be evolved from the fabric. (*Ibid.*, p. 430, 431, n. 286, *g.*) We are to inquire how use brings forth use, since there is a chain of all things. (Part II., p. 141, n. 393; p. 361—366, n. 464—466, and the notes.) All things that are produced successively, are fashioned before, and according to, the use that they will afterwards perform. (*Economy of the Animal Kingdom,* tr. i.,

It is in a manner the soul, while the fabric is its organic subject, or the body of that soul. We see a sufficiently lively specimen and example of this in the mind itself, thus in our very selves. When the mind intends to accomplish a predetermined end, it contrives and sets up as it were suitable fabrics to promote the end; in other words, it conceives and brings forth series of efficients, or chains of means, which it reduces to ultimate order in mutual subordination to each other, so that by them, thus put together, it may move onwards with incessant advance and with a firm step to the effect or use of the end. There are as many mirrors of uses, or of progression from the first end to the last, as there are organs and viscera, and parts of these, even least parts, in the body. The *muscle*, from the first stamen, tends and is bent to its use with unerring direction, and in the completed series of its moving fibres, it straightway assumes and puts on the image of its use, which in fine it so exactly represents and effigies, that nothing can be involved in the motion or action to be produced, which is its use, that it does not possess, and when the will of the mind commands, evolve into act (*n*). The *gland*, of whatever kind it be, whether

n. 251.) So that everything is a means to some ulterior use or end; so always, that while it is placed in the middle, it contains the ratio of the things following it, and refers itself to those going before it, upon which it depends, and for the sake of which it exists in its own distinctive manner. (*Ibid.*, n. 252; and tr. ii., n. 365.)

(*n*) If we well consider any muscle, and its innermost fibres, and the moving fibres composed of these, and their arrangement for a preappointed use, we shall see clearly, that as many species of motion as there are fibres may be produced from such muscle; at any rate, as there are fibres that can coöperate with their companions, and with those of other muscles: not to mention degrees of celerity. Thus the variations and differences of uses easily rise to something like infinity, or elude our most subtle calculations. The muscle is immediately born and introduced into these uses by its first fibre: so that there is a use that is conceived in our highest mind, and determines all things; and that this mind aspires to a kind of infinity, is evident from a mere contemplation of uses. Nothing that is in any way possible can be offered, within a given sphere, in the execution of uses, that does not appear imprinted upon the organ that is to execute it.

glome or globe, in like manner grows into all the series and instrumentality, and at last into the full effigy of its use. The same may be said of all the *viscera* of the organic body (*o*); for when you term them machines of effects, you also term them series of ends and uses, which govern the fibres and vessels from the first causes to the last, just as a charioteer governs the reins of his chariot to the goal and the palm. So also touch, which is the use of the papillary cutis, constantly weaves together the fibres and stamina to the likeness and on the model of itself, in order that this sense may stand forth and appear in its real character in the organ, and *vice versâ*, the organ in the sense; for whatever can possibly be involved in touch, is found inwoven and innate in its organ.

532. *In general, the organic forms of the body, whether they be sensoria, or muscles, or viscera, are perfect in proportion to the simplicity of the forms or ideas that they commence from, and which are their unities.* Every form or series has its proper unities (*p*). The lungs have vesicles as unities: the liver and the pancreas, glands, and what are termed the hepatic pores:

(*o*) I should be entering on an immense field, if I were to recount only in general the uses of each viscus, so as by this means to procure a universal idea; for this is the primary object of our analytic investigations; also, that from the representation of uses in the body, we may be the better informed and instructed respecting the intuition of ends in the soul, whence spring the uses, (that are there represented as ends,) which we contemplate in the fabrics of the body.

(*p*) I have treated throughout in the foregoing Parts of the unities of the viscera, which I have occasionally called simples and leasts. Thus: The moving fibres are the simples of muscle. (Part I., p. 53, n. 44.) The lesser glands, and the papillæ, are simples of their kind. (*Ibid.*, n. 44, note *i.*) Whatever is seen in compounds, arises out of simples. (*Ibid.*, p. 129, 130, n. 100.) The stomach consists of simpler stomachs, that act more perfectly and more universally. (*Ibid.*, p. 130—133, n. 101—103, notes *p* and *s.*) And congregate entities stand related to their unities, as to their simplest parts: but by unities we do not at all mean the monads of Morinus,* the homœomeriæ of Anaxagoras of Clazomenæ, or the atoms of Epicurus; or the elements, primitives, and

* Swedenborg says, "*monades Mori*," but I presume he alludes to J. B. Morinus, who wrote *De Atomis et Vacuo*. I cannot find any one named Morus who has treated of the subject.—(*Tr.*)

the spleen, polygonal cells: the ureters, the stamina of the cortical substance of the kidneys; and then the tubuli Belli-

simples of some authors, so far as they are understood to be indivisible; but those things that are the least in each series, and enter its form, as its essential parts; and which are proper to it, and would not suit any other series or form if they were applied to it. (*Economy of the Animal Kingdom*, tr. i., n. 629, 630, 631.) In order that we might be enabled to procure a clearer idea of the division of a compound down to its unities, I have proceeded by real instances, confirmed in the proper places by many proofs, and which illustrate at the same time that they confirm. Let us recur to one only; namely, to what we said of the pulmonary vesicles. It is sufficiently certain that the pulmonary vesicle is the unity of the lungs as regards their respiratory office, inasmuch as there is no lesser cavity into which the air can penetrate, and inasmuch as the lungs exist and are called the lungs, from their vesicles. Whatever goes beyond the vesicles, or whatever that is more simple exists within them, as the fibre or capillary vessel that enters the composition of the vesicle, cannot be called the proper unity of the lungs, for the fibres and vessels universally determine every fabric of the body. To the lungs or their unities belong only the organic texture or form that those fibres and vessels generate, to produce the vesicle. The like obtains in all other parts, whether they be organs or viscera. Furthermore, it is to be observed, that different kinds of unities may coexist in one viscus; namely, unities that pertain to different functions. Thus in the lungs we have the cells or follicles on the outside of the vesicles or bronchial branches, into which follicles the serum of the blood is thrown by the venous artery; for these pertain to its office as a purificatory of the blood. The same thing is exemplified in the tongue; its pyramidal papillæ belong to its gustatory function; the glands with which its surface is beset, to its libatory function; the muscular fibres, as unities, to its motory function. It is absolutely necessary to form a distinct idea and perception of unities; for thereby many phenomena that would otherwise lie quite buried and hidden till the end of time under a mere controversy respecting divisibility of parts, are brought out of darkness into some degree of light. Boerhaave dissertates ingeniously to the following effect on the subject of divisibility: "All the solid parts of the body," says he, "are constituted of other lesser parts, as like as possible to the larger; vessels, of little vessels; bones, of little bones; and this fabric proceeds altogether beyond the limit of the senses, however assisted by artificial means, as Malpighi, Ruysch, Leeuwenhoek, and Hooke have clearly shewn by experiment. Yet this division seems

niani: the brains have the cortical glands and simple fibres: the muscles, moving fibres: the tongue, the œsophagus and the stomach also have their unities: the eye has the filaments and villi of the retina as unities: the organs of smell, taste and touch, have papilliform fibres. The power, efficacy, and nature of these unities are determined by the form that is bestowed upon them by the fibres and vessels (*q*). Similar unities are to be admitted in all accidents, modes, and other adjuncts of which any form is predicable, as in substances as subjects [of accidents, modes, &c.] These unities are noble in nature and essence, in proportion to the priority and height of their origin and extraction, because in this proportion they are related and proximate to the first unities, from which the perfection of all the succeeding unities is derived; and thereby are of a more illustrious stock, or if I may be allowed the expression, of a more celestial lineage. Take as an instance the unities of the cortical substances of the brain, which are set in the highest place and in the greatest state, and derive their origin direct from the simplest and omniparent fibres, and in a manner have their descent from heaven. But not so the organs and viscera of the lower sphere, which are more ignoble, inasmuch as they are sprung from compound fibres, and from vessels. The papillary forms of the cutis, or touch, do not derive their unities from so high a source as do taste and smell: nor the latter from so deep a ground as do hearing and sight: for which reason the very fibres of the latter are comparatively

scarcely to go on to infinity, so far as we can learn from the nature of the food and humors." (*Inst. Med.*, n. 439.) But as we see, he here extends the divisibility down to the minutest fibrillæ: thus beyond the proper unities of each member.

(*q*) These unities have been mentioned and described throughout, in their places, where we have treated of the above viscera. For it is impossible to arrive at a knowledge of the use of the viscera, unless at the same time of their unities; since from these, the viscera derive their first powers and natures, but their second nature from the form and determination in the composition of these. To this point it behoves us to pursue and scrutinize bodies analytically, unless we would stick and wander in the crust and surface alone, without ever breaking the shell, and penetrating to the kernel, or to interior things.

delicate and soft from their first origin or birth; I allude to the fibres of the olfactory, auditory, and optic nerves; for the fibres by which the forms are to be generated, are adapted from the first stamen to every kind of variety and idea of use in the extremes (n. 531); so that there is always a rise in dignity according to the value of the unities. It is easy to understand, that unities are quantities great and small, and even in some cases integers and totals, from the indeterminate arithmetical unities and numbers determined and applied to use in household economy, mechanics, statics, astronomy, music, anatomy, surveying, &c. (*r*).

533. *The unities of organs associate together mutually, and the associations so formed, again combine: thus unities generally ascend to the third series or dimension of composition before they complete their determinations.* Such is the case in the nerves, the muscles, the viscera of both regions, the sensorial organs, and their common sensorium, the cerebrum (*s*). The fibres of

(*r*) It will be plain that unities are predicated of the greatest things as well as of the least, if we only consider that unities do not respect leasts, but individuals. The unities of human society are men, thus entire bodies; the unities of the muscular system are entire muscles. A weight is styled one, and a measure one, the greatest as well as the least: nay, universes are termed units or unities, if they be compared with their likes. Wherefore each series form, and substance is considered as a unity by itself; but the unities of the series itself, are those from which it exists and subsists. These points, however, are too well known to require any commentator or expositor.

(*s*) In order that we may understand how the formations of things take place, or how forms exist, we must attend particularly to those forms that are displayed in the animal body; in the generation of which, all that is most mysterious in nature, consequently in the whole of human science and art, is heaped together and concentrated. From these forms, as the last, we may conclude analytically to nature's other forms, as prior to these; to those, namely, that obtain in the vegetable and mineral kingdoms, and in the atmospheric world; and even to the forms of human societies; in a word, to everything of which form is predicated; that is, to everything that can exist; for it derives from its form the fact that it is something and has some quality. On this threshold, where we are speaking of the external senses, I have considered it right to bring together these particulars that belong to

the *nerves*, when joined and set together, make a little nerve or bundle that serves as a new principle; and a number of these little bundles again conjoined, produce the entire bundle termed a nerve (*t*). The first-born moving fibres of the *muscles* by their association generate a visible fibre, properly the moving fibre; a number of the latter again by their coördination generate the muscle. The vesicles of the *lungs*, as scattered grapes, unite into lobules like clusters; and these lobules again, by means of the bronchial vessels and pipes, unite into lobes, as it were the boughs of the vine, of which lobes the lung is made up (*u*). The same may be said of the glands of the *liver*, which put together in the first instance, by means of the vessels and pori bilarii, rise into lobules; which lobules again combining, complete the mass of the body of the organ (*x*). And also of the

forms generally; for the sensoria, like the viscera, are nothing but organic forms, although exhibiting among them a wonderful play of variety; but if they were explored one by one according to their varieties, without a common notion of forms, our ideas would certainly not be collected, but dissipated; for every organ differs specifically from every other; but in these predicates that are now being explained, they all agree entirely.

(*t*) Everything in the visible world has its determinate greatest and least, or maximum and minimum, and proceeds from its maximum to its minimum, and from its minimum to its maximum; so it is with the blood-vessels, and so with the nerves. (*Economy of the Animal Kingdom*, tr. i., n. 156—161.) In our Parts on the Cerebrum and the Nerves, we shall shew from the ocular experience of many authors, that the nerves derive their primary origin from fibres, and that the fibres unite together into a fine fasciculus also called a nervule or little nerve, or while it is yet within the cranium or the vertebral theca, a principle of nerve; and that these little nerves compose the nerve itself. Likewise, that the muscles derive their origin from the least motricular fibres, which are gathered together into a larger fasciculus called a moving fibre, of [a number of] which the muscle is formed.

(*u*) Respecting the formation and origin of the lungs from vesicles, lobules and lobes, see Heister, Part II., p. 121, n. 385; Winslow, *ibid.*, p. 124, 125, n. 387; Malpighi, *ibid.*, p. 128—131, n. 388, 389. See also the Analysis of the Lungs throughout.

(*x*) See the description of the liver by Heister, Part I., p. 253—255,

pancreas, which commencing from its glandular follicles disposed in masses, grows to its dimension, and becomes a body (*y*). The *thymus* also from similar beginnings fitly conglomerated, springs up into a considerable gland. The urinary tubules of the *kidneys*, associated together into conical or pyramidal sections, and these sections themselves again associated, complete their ultimate dimension (*z*). The buds or glands of the cortical substance of the *cerebrum* are accurately fitted one to another, and by means of the blood-vessels, unite into little balls or glomes; these again combined, produce new series, by the spiral circumvolution or convolution of which the cerebrum itself is generated. Something analogous is evidently the case with the *papillary substance of the cutis;* this is woven in the first instance of the finest fibres, which are then grouped together to form papillæ, and from the association again of these papillæ, the true organ of touch, or the last of the sensoria, receives its form and attains its completeness (*a*). Nature goes through similar steps, and mounts by the same scale of progressive elevation, in all the other organs (*b*); and beginning from

n. 191; by Winslow, *ibid.*, p. 256—259, n. 194; by Malpighi, p. 261, 262, n. 197.

(*y*) This becomes still more evident from the descriptions and delineations of the pancreas. (Part I., p. 306—309, n. 219—224.)

(*z*) See the description of the Kidneys by Heister, Part I., p. 415, 416, n. 278; by Winslow, *ibid.*, p. 416—418, n. 280; and particularly by Malpighi, *ibid.*, p. 420—424, n. 282; who also shews, that the kidneys of some animals are not divided into pyramidal sections, as in man, but into lobules, like the other glandular viscera.

(*a*) We shall have an opportunity of shewing in the sequel, that the first unities of the papillary organ, or of the touch, of the cutis, are not the papillæ themselves, but the fibres that construct the papillæ; also that the papillæ are disposed again in circular, spiral, or other series.

(*b*) There are moreover compositions that do not rise further from their unities than the second series or division of composition; for instance, certain of the more simple and uniform glands, which in fact are not seen to be divided into lobules. There are others again that go as high as the fourth degree of composition; for example, the cerebrum; also certain trunks of nerves, as the great brachial and crural

her unities, or from her leasts, simples, principles, elements, or as it were points and lines, and thus advancing by repeated compositions, ascends, or rather descends, until she reaches the last series, and so produces a body of trine dimension.

534. *These series, or bodies of trine dimension, viscera, members or organs, are at the same time conjoined by bonds; the unities themselves, by theirs; the series proximately derived from the unities, by theirs; finally the composition itself, or the whole; which is covered with a coat, as the bond of all, or the common bond, from which the little coats and bonds of the other parts proceed, whereby the parts are bound to the common service, and live in a harmonious division of labor.* In order that all things may be joined by individual consent, and that generals may side harmonically with the parts of their parts, and agree with them, they are wonderfully conjoined by bonds into a form of society. From the proximate or proper common coat of the *nerves* stamina are given off, that bind the fascicles, and from the coats of the fascicles again, stamina that bind the fibres, and thus ally the parts to the general. From the sheaths of the *muscles* cords are similarly detached, that both connect and tie down the visible moving fibres; from these again fresh cords proceed, that associate the invisible and likewise moving fibres. From the common integument of the *liver* membranes are separated, that clothe the lobes; and at the same time capsules and sheaths proceed, that cover over and bind down the glands or unities; and this, in order that the parts may stand by the compound, and that the compound may stand by the parts. The same thing occurs in the *pancreas*, the *spleen*, the *kidneys*, the *renal capsules*, the *lungs*, and the other members of this kingdom (*c*). In the *brains*, in the most becoming order of all, from the proximate or proper membrane proceed vascular

trunks, in which a number of nerves are enclosed together in a common tunic. But we find that order the most usual, which proceeds from its simple to the third degree of altitude or composition. I have not thought it necessary to prove these points in greater detail, since they only involve the form or conformation of the viscus, which is given in the descriptions and plates of all anatomical authors.

(*c*) These again are mere objects of experience, forasmuch as they belong to form, and are found and demonstrated by every anatomist;

congeries, which like soft tunics invest the cortical spherules; from these tunics and at the same time from the pia mater offsets are detached that clothe each part of the cortex with a most delicate membrane, or piissima mater: hence there arises an individual concurrence or consent of all under the general auspices. Likewise in the *papillary organ of the cutis*; from the corpus reticulare, as from a common bond, little vascular branches or leaves come off that cover the several papillæ; from

the fact, I mean, that the nerves, the muscles, the conglobate glands, the cerebrum, and many other organs as well as viscera, are encompassed by two membranes; and that from the inner, which is the proper membrane of the viscus, connecting cords are seen to be produced, that go to every part, and even invest it with a little tunic propagated therefrom. Simply to instance the glands of the liver. "Each glandular granule [of the liver]," says Winslow, "is bounded and in a manner invested by a particular expansion of the capsule of Glisson: and all these expansions are held together by common septa, almost like the cells of a bee-hive." (Part I., p. 259, n. 194.) The same thing will be found to hold good with the brains and the nerves, when we come to the description of them. So usual is the plan of binding together particulars by ligaments produced from the common tunic, that it is never departed from in any of the viscera. But with respect to the more common membrane with which they are for the most part surrounded, it appears to be taken on for the purpose of again attaching the viscus or member to a more common coat or bond, as the parts are attached to theirs; to wit, to the peritonæum, the pleura, or the diaphragm, to which likewise ligaments proceed, as from the lungs, the liver, the stomach, the intestines, the pancreas, the kidneys, the succenturiate kidneys, the ureters, the bladder, the uterus: thus the same plan is followed in the greatest and least things. Everything refers itself to its general, in order that scattered modes may be collected into one. (Part I., p. 53, 54, n. 44, 45, *k*, *l*.) And this is brought about by means of tunics. (*Ibid.*, p. 54, 55, n. 45, 46, *o*.) The common covering propagates itself to all parts. (*Ibid.*, p. 494, 495, n. 320.) All the viscera of the thorax, and all the viscera of the abdomen, stand related to the diaphragm as the most common covering and bond. (Part II., p. 300, 301, n. 446.) The pleura, the peritonæum, and the diaphragm put forth ligaments to all the viscera. (*Ibid.*, 301—303, n. 447.) It is in the least things as in the greatest. (Analysis of the Peritonæum, *passim*.)

the surface of the papillæ again proceed the most delicate bonds, which run to every fibre of the papilla, and surround it; or what amounts to the same thing, from each parent fibre, little chains and ligaments run to the little coat or bark of the papilla; from this again fresh ligaments run to the corpus reticulare, which sustains, strengthens, and balances all the papillæ (n. 498), gathers together scattered parts, gives them distinctness, reduces them to form, and thus causes everything to refer itself to a general (n. 499), and which serves as a link and instrument of union to the papillary substance, the glands, and the fat (n. 497). By virtue of such concatenation, nothing but harmony and consistency can arise, and the same thing is enabled to appear one to all.

535. *Nevertheless, organic forms are perfect, in proportion as the several parts that essentially enter and compose the form, are placed distinctly with respect to each other; but yet concur unanimously to produce common effects and uses.* For every part has its own form given, its own nature, its own power, its own force: to every form this is imparted, in order that it may be the cause of an effect, and the contributor of a use: such is the case in every society, whether living or dead. For the more distinctly any individual thing acts, the more distinctly it lives; the more freely the blood circulates through its vessels, the spirit through its fibres; the more harmoniously with its heart does it beat, with its lungs does it respire, and with its brain does it animate; and so vies with its companions in obedience and contends for the reward. That the greatest and the least things are placed distinctly with regard to each other, is apparent from the several fibres of the nerves, and from the several fibres of the muscles; from the several vesicles and cells of the lungs; from the several glands of the liver, the pancreas, and the thymus; from the several tubules of the kidneys; from the several substances of the cerebrum; and from the several papillæ of the nares, the tongue, and the cutis: for all these, like little wheels of an axis, are circumscribed in their sphere of activity, surrounded with watery moisture, and besmeared on all sides with unctuous humor (*d*). Without descending to

(*d*) See Part II., p. 269, 270, n. 433 (*a*), where this was suffi-

the case of minute animalcules, we have a remarkable exemplification of the great mutual distinctness of these least forms in young subjects, while the internal and external powers are inchoate, in our own embryos and infants, where everything is moveable every way, articulate, capable of perspiring, and so of conspiring; and this, down to the very tendons, cartilages, and bones; which become concrete as we recede from the life of this life; that is to say, the muscles grow tendinous, the tendons become cartilaginous, the cartilages ossify, the vessels are blocked up with slime, the fibres are forced into contact with other fibres, the pores become imperspirable: thus life advances to its goal, and declines to solid age. But the powers then betake themselves inwards, from the body to the mind, so that the latter may stand on the threshold ready to ascend to the higher or still more internal sphere. Again, this same mind is obscure in proportion as it is indistinct, but bright in proportion as it is distinct; in the former case presenting the appearance of death; in the latter, the appearance of life.

536. *Organic forms again are perfect in proportion as their unities and compounds stand related to a similar type, and shew themselves to be of one genus, in their power and manner of acting. Also in proportion as the parts of the same organ are specifically distinguished from their companions by differences and variety, and at the same time are conjoined with them in fitting harmony.* With respect to the first point, equations and com-

ciently proved by the instance of the thymus gland: it is also confirmed in several places in the present Part, by the phenomena of the Sanctorian perspiration. And it is further evident from this consideration, that unless the moving fibre were left to its own state, or at liberty, it could in nowise admit of being expanded and contracted among its associates, to suit every form of action commanded. Unless each pulmonary vesicle were expansile and contractile in the most free manner in its place, the lungs could in nowise bring out all the vastly different and numerous modes of respiration that are required in speaking and singing. Unless the gland possessed the most liberal power of expansion and constriction, it could not so promptly attract the essences, or throw them out through its little emissary ducts according to every emergency of use, &c.

positions, like numbers, are homogeneous with their unities (*e*). Every subject has its nature communicated to and implanted in it by its ground, and as it were by its seed; hence the liver obtains from its glands its power to refine the chyle, and to generate the new blood. The pancreas [obtains from its glands the power] to prepare a menstrual juice for the intestines, and together with the spleen, to send the cruor to the liver, for it to lustrate and impregnate with chyle. The stomach and intestines obtain from their primitives the power to triturate and digest the food, and reduce it to an innocuous and nutritious juice. The lungs derive from their cells the power to teaze the serum; and from their vesicles, the power to animate the kingdom by the breath. Since therefore the viscera, whatever their function may be, educe from their leasts their power of operating, hence it would not be admissible to substitute a part of one viscus for a part of another; for instance, to insert a gland of the liver into the pancreas; nor to engraft a gland of the pancreas into the thymus, still less into the brain; nor to put a cell of the spleen, the peritonæum, or the pleura, into the lungs; nor to plant a sensorial papilla of the cutis upon the tongue; nor to give a papilla of the tongue a place in the nares. And again it would be equally unlawful to confound the ducts and pores of one viscus with those of another; as the hepatic with the cystic, or the cystic with the pancreatic. As in the least sphere so also in the greatest: it is not lawful to put or substitute one muscle in the place of another, to put the œsophagus in the place of the trachea, or the kidneys for the testicles; for in the one case, by virtue of the principles themselves, the whole with its part, the compound with the simple, or the viscus with its single elements, whether these be glands, or

(*e*) On this subject we refer the reader to our *Economy of the Animal Kingdom*, where he will find the same thing illustrated by many examples and considerations. Thus it was shewn that aggregate entities of the same degree and series stand related to their unities, as to their simplest parts,, with which they are homogeneous. (tr. i., n. 629, 630.) From the form, nature, and mode of operation of such aggregates, we know what is the form, nature, and mode of operation of their parts. (*Ibid.*, n. 631.)

ducts, or vessels, or fibres, do not accord to one and the same thing as in the other. This is also evident from the felt propriety of denominating each part from its whole, and the whole from its part. A little vesicle of the lung may not inappropriately be termed a lung in the least form; a lung, on the other hand, a great pneumonic vesicle: the same rule may be applied to the little bronchial branches of the lung, in that they are so many lesser tracheolæ. To a muscle, as a great moving fibre; and to a moving fibre, in a similar type, as a least muscle. Likewise to a nerve, as a great fibre; and to a fibre, on the other hand, as a least nerve. Precisely in the same manner the liver is a great gland, and its part a least liver. The Bellinian tubules of the kidneys are least ureters. And the very same obtains in the stomach, the heart, the tongue, and all the sensorial organs (*f*). For the likeness and image of the greatest is represented as in a mirror in the least, and of the least in the greatest. The character and nature of the genus is propagated all the way from the little seeds and ova, into every species and product however multiplied and enlarged: thus one thing is brought over into the meaning and idea, and even into the name, of another. But the above-mentioned differences and varieties that the viscera and organs mutually derive from their stock or root, or from the form and essence of the unities,

(*f*) The reader will see these points explained more fully in Parts I. and II. of the present Work, where we were busied in examining the viscera themselves. Thus: simples or unities are the models and ideas of compounds. (Part I., p. 53, n. 44, *i.*) Compound forms consist of similar simpler forms. (*Ibid.*, p. 129, 130, n. 100.) Whatever is seen in compounds, arises out of simples. (*Ibid.*) The stomach consists of simpler types, or as it were least stomachs. (*Ibid.*, p. 130—132, n. 101, 102 (*p*, *s*); p. 132, 133, n. 103.) The lungs are a continuous ramification of the trachea. (Part II., p. 93, n. 372.) The tongue does the same in its leasts [as in its compound], and in the leasts, indeed, more universally. (Part i., p. 36, 37, n. 34.) There are least, larger, and largest ureters. (*Ibid.*, p. 444, n. 289, *f.*) And again: the lacunæ in the heart are so many lesser cardiac chambers or ventricles: and the cortical glands of the cerebrum are so many cerebella in the smallest form, that is to say, cerebellula. (*Economy of the Animal Kingdom*, tr. i., on the Heart; and tr. ii., on the Cortical Substance.)

are generic; there are also specific differences and varieties between every part or unity of the same viscus(*g*), just as between the individual subjects of the most multiplied progeny or posterity that descends from one parent; or as between the trees of some great forest propagated in succession from one seed, or from the seed of one tree; and as between the branches of one tree, or the leaves on one branch; between the vessels of one heart; the fibres of one brain; the papillæ of one skin, tongue, or stomach; or going deeper still, between the formative fibres in the papillæ. These fibres, the minutest types of papillæ, are united to each other with more exquisite harmony than the papillæ themselves; for forms are perfect in proportion to the simplicity of the ideas that they commence from, or to the depth of their grounds (n. 532). All proportion, analogy, and relation perish in equality; and all sensation likewise, whether of touch, taste, smell, hearing, or sight; because the representation of one part of an object in another perishes, and the correspondence and harmony of each part with each; and indeed, what is remarkable, union or unity itself altogether disappears in equality, because concord disappears; as plainly shewn by the following analytic chain; viz.: in nature there is no *one* thing that is not something; nor is there any something that is not some quality or some quantity, nor is there any quantity that is not some quotum. In order for any quotum to become *one*, it must arise from a number of parts [*aliquot*], which must consent or accord, thus from various things that agree by a kind of har-

(*g*) There is perpetual variety in nature, and the perfection of her world results therefrom. (Part i., p. 55, 56, n. 47 (*p*); Part II., p. 52, 53, n. 361.) There is a variety in all things between the parts and members of every society. (Part II., p. 363, n. 464, *o*.) The established order is perfect, in proportion as the simpler substances are more distinctly discriminated from the more compound substances. (*Economy of the Animal Kingdom*, tr. i., n. 602.) And again, the established order is perfect, in proportion as substances of the same series or degree are well distinguished from their associates, their essence and attributes remaining permanent. (*Ibid.*, n. 603.) Consequently there is harmonic variety. (*Ibid.*, n. 604—606.)

(*h*) This argumentation by a logical chain from unity, to its causes, and so back to unity, may be confirmed in many ways; as, that in

mony, and so are *united* (*h*). But the reader may pass over these and similar statements if he pleases.

537. ***The sensoria, motoria, viscera, in a word, the organs and members of the body, and their parts, are perfect in proportion to the promptitude and ease with which they can change their states, and after change, recover their pristine natural state, and preserve it unimpaired.*** Nothing can be more versatile than the organic forms of the living body, and of the circumambient world; in fact, they are born for perpetual adaptations and changes. The modifications of the world, and our sensations, external and internal; determinations and actions, natural and voluntary; the functions and operations of every viscus and member, are mere mutations, running in a chain, in circles, and in spires, from the outermost spheres of parts to the middle and the innermost, or from the innermost to the middle and the outermost. For bodies or parts are either brought out of their places, and leave their centres, which is a *change of station;* or are rotated round an axis or points holding the place of a centre, which is a *turning of circumference,* or of parts of the circumference; or are disturbed in the connexion and position of their constituents, which is a *change of form;* or swell out

nature there is no *one thing* that is not *something;* for unity cannot be predicated of nothing, *ens rationis*, nonentity, vacuum, or inanity; a vacant space cannot be called a space; wherefore the oneness that belongs to space, is not attributable to it. So neither can unity be predicated of the mathematical point, nor of the point or sign *d* in the differential calculus; wherefore nothing can be given to this by addition. Of these or of similar things we cannot speak as of *something*, or as of *a something;* since they are only *entia rationalia :* wherefore *something*, as it is conceived, does not exist in the world of nature without the real existence of *quality* or *quantity ;* this again involves *number* or *quotum*. Quantity is not possible without more things than one; nor is a thing called one except with relation to another thing. Hence in order that any quotum, or quantity, or thing may be represented as *one*, it must necessarily involve the principle of plurality, or the existence of several things that can so agree as to present the appearance of oneness. Every form and substance is such a unity, and therefore I have not hesitated to assert, that there is nothing in the visible world but is a series, and in a series. (*Economy of the Animal Kingdom*, tr. i., n. 586.)

and fall back again in their places, which is a *variation of measure* or magnitude; in one word, a *change of state. Human faces* themselves exhibit a lively image and expression of these changes; for there is no affection of sensation, no delight, passion, or appetite, of the animal mind, and no desire of an end, or regard of good or evil, that does not imprint some type of itself upon them (*i*). So likewise do the *lips*, the *tongue*, the *palate*,

(*i*) This is a matter of such vast extensiveness and immense importance, that it is impossible to state it in a few words without the risk of obscurity. With respect to the *extensiveness* of this matter, it will require, to explain it, that we run through not only the whole animal kingdom, but also its two ministering kingdoms, the vegetable, namely, and the mineral; and furthermore the atmospheres, which constantly sustain those kingdoms by their powers and forces, and reduce them to the rules of the universe of nature. Such then is its extensiveness, and such its field, that it is all important and pervading in nearly all the learning derived from nature's bosom. For whatever exists in act, and falls under sense and apprehension, supposes mutation or change. Things that exist, lie idle, without mutation, folded up in mere potency; nor do they open out and display their qualities, unless they become forces; which cannot happen without change or some activity. From these considerations it follows, that no *point* in learning takes precedence of this, or is more worthy to be known. In the present Chapter I have endeavored to reduce the heads of things to a few words. But in all the subjects that have hitherto been investigated, and that are afterwards to be investigated, hardly anything occurs but varieties of mutations according to given and substantive forms, and hence we have confirmations presenting themselves continually. Nevertheless, in order that I may give a still more clear idea of these changes in general, I will simply subjoin to what has been already said, the following,—That there are four species, or if you please, genera of changes, to which all the others are referable: namely, a *first*, that takes place by local motion, with transference of the centre itself, as of our whole body, and its members,—the feet, the soles of the feet, the arms, the fingers, the ribs, the vertebræ: all actions are presented by these changes. There are similar changes also in many other members, as in the lips, the tongue, the cheek, the palate, the larynx, the trachea, &c.; and which appear as manifest changes, because they are so developed out of the little motions of parts as to strike the very senses. Again to this class may in some sense be referred the

the *uvula*, and with them, the *larynx*, the *trachea*, the *lungs*; or else with them, the *pharynx*, the *æsophagus*, and the *stomach*, and with these again the viscera of the abdominal region. For the *lips* and the *tongue* with the *palate* turn, roll and twist into all possible forms of motion, correspondently to every tone, measure, and division of sound, speech, and singing; and to-

circulation of the fluids, as the blood, and others. I have called this species, *change of station*. The *second* takes place by *turning of the circumference*, or of parts of the circumference, the centre of the organ remaining in its station; for a rotation is made around its axis; as in the case of the eye, which gyrates in every possible direction by means of its muscles, so that wherever objects happen to be, they fall in lines on the pupil and lens, and the eye takes their dimensions by its sense. Similar arthrodial circumvolutions exist again in other parts, as in the joints, the motions and actions of which respect some fixed centre, round which they turn. For action is a certain form generated by the motion of the muscles. To this species also might be referred the circulation of the blood through the vessels, in so far as the heart is regarded as the common centre of that circulation. The *third*, or *internal change of form*, takes place by the disturbance of the connexion and position of parts; thus by the change of the whole form into some different form, as of a circular form into an oval, or some other simple or compound form belonging to the family of curves, or else into an angular form: as in the sensorium of touch, the papillæ of which are altered in figure according to every idea [entertained] of the thing impressed, or every figure of the object impressing; and in the motoria or muscles, which are altered in figure according to every intimation of the will: also in the other viscera, when they are twisted and bent in unevenly by their neighbors; particularly in the pipes, great and small, as in the trachea and the œsophagus, and in the mouth and the glottis, which may be developed into all species of figures. The *fourth*, or *variation of magnitude* or measure, the form itself being permanent: This simply respects the quantity of the form, as the former respects its quality; as when the lungs are expanded and contracted by their respirations; the cerebrum, by its animations; the heart, by its systoles and diastoles; and the viscera of the whole body, by the same: for nothing of form perishes by either simple enlargement or diminution, forasmuch as the same nexus and position [of parts] remain in the larger as in the lesser type: wherefore this change is natural, but the others are voluntary, and first begin to exist when the will is taken

gether with them the *larynx*, the *trachea*, and the *lungs*: also correspondently to every variety in the contact, advance, and passage of the food, solid and fluid, with a reference to its mass and taste; and in this case together with the same organs, the *pharynx*, the *œsophagus*, and the *stomach*; and with these, the other members of the abdominal region. The *sensoria* of the body and the head, or the *external* sensoria, bend, move, vibrate, open, or contract, at every impression of an object. The *muscles* do likewise at every command of the will, and body forth actions exactly answering to the idea predetermined by the mind. Nor must we omit what takes place in the superior sphere of the body: every image that is raised into an idea, every idea that is raised into the element of a reason, every reason that is raised into an analysis, and analysis that is raised into a decree, is a mere mutation of the principle or beginning of the sensoria. In a word, the events of our active life are nothing but changes of the substances of life, which thus modify their forces. Which is the reason that organic forms are perfect, in proportion as the several parts that essentially enter and compose the form, are placed distinctly with respect to each other (n. 535). But whatever change forms enter upon and undergo, still they incessantly tend to fall back to the natural state; so constantly does nature govern the reins of the will (*k*).

into fellowship with nature. Meanwhile, we have treated occasionally of these mutations or changes in the preceding essays: as, that the viscera undergo many changes, and perform their offices according to those changes: and that the kidneys secrete and excrete the urine so variously according to the same. (Part I., p. 454—456, n. 295, *f*.) The larynx can open the glottis into all possible measures, figures, and forms. (Part II., p. 53—56, n. 361.) Suitably to the whole nature of sound, and the correspondent condition of the palate, the tongue, and the mouth. (*Ibid.*, p. 62, 63, n. 363; p. 68, 69, n. 364.) Likewise the trachea. (*Ibid.*, p. 95—97, n. 374 (*c*, *d*) *seqq.*) Also the lungs. (*Ibid.*, p. 162—165, n. 399, 400; particularly p. 95—97, n. 374.) And the other viscera, respecting which we refer the reader to the Chapters where they are treated of.

(*k*) Every voluntary action tends to produce a change of the natural state. (Part II., p. 166, 167, n. 401, *n*.) And nature every time restores that state. (*Ibid.*, p. 165, n. 400, *m*.)

538. *Unities are the centres of their viscus or organ; and they are the beginnings and ends of its determinations; also the first forces and efficient causes of its effects, and determinant causes of its uses, so far as they are uses. But the reason why the unity is such a cause, is contained in its form.* The unities that construct the organic forms of the viscera and members of the body, are not of one kind only, but of many kinds; they are either glands, or cells, or fibres with vessels, or papillæ, but still they are unities. For effects and operations go no higher than to them and from them; in them, as in their last boundaries, they end; and from them, as from their first boundaries, they begin: whatever lies deeper, is in the very forms of the unities, and in the fibres determining those forms, as the principle of the cause, the reason of its particular quality, the end, or the ground of its distinctive use. From *glands*, as their centres, all the conglomerate glands begin; as the thymus, the parotid and maxillary glands, and many others; likewise the pancreas, the liver, the cerebrum, the cerebellum, and the medulla oblongata and spinalis. The lungs, the spleen and the conglobate glands commence from *cells;* and the common coats of nearly all the viscera, as the diaphragm, the peritonæum, the pleura, and also the omentum and the mesentery, are made up of the same. From *fibres and vessels* of some kind originate the sensorial organs, the eye, the ear, the papillæ of smell, taste and touch, the muscles, the uniform membranes. From *papillæ* begin the outermost coats of the cutis, and of the tongue and nares, and the innermost coats of the œsophagus, the stomach, the intestines, the ureters, the bladder (*l*). These

(*l*) There are members or organic compositions in the body, that have not arisen merely from glands as unities, but also at the same time from cells; nay, there are some that have arisen at the same time from fibres, and from papillæ: for instance, those viscera that are purely membranous, because hollow, as the stomach, the intestines, the urinary bladder, the ureters, the œsophagus, the trachea, and even the tongue: and there are some that have a threefold, and some that have a twofold origin: but those that are of simple origin have been mentioned in this Chapter, lest accumulated varieties should cause obscurity. To take as instances only the stomach and the tongue. The

unities are centres, wherever placed, whether in the middle of their viscus, or whether in any radius, axis, or periphery of its compound form: as the glands of the cortical substance of the cerebrum, which crown its circumference; the glands of the cineritious substance of the cerebellum, which follow its lamellæ or folds and arborescent leaves; the glands of the corpora striata and medulla oblongata, which are intermingled ray-wise among the fibrillary texture of those parts; the glands of the spinal marrow, which compose its median axis: or the glands of the liver, which occupy its lobes and spaces throughout: the vesicles of the lungs, which like the grapes of a leafy vine, both fill the interiors and beset the surface: likewise the cells of the spleen, which make up the whole mass of the organ. Or the fibres with vessels, that generate the sensorial and motorial organs especially. These glands, vesicles, fibres, or papillæ, wherever found to be situated, are the last and first boundaries, or

stomach, a mere tunicated cavity, has on its inner surface a villous coat, of which the unities are papillæ; next a glandular coat, where glands prevail as origins; then a muscular coat, in which moving fibre is everything; and then a cellular coat, the primitive or single elements of which are cells. In the *tongue* there are muscular fibres in its interior substance, but near the surface, a glandular and papillary congeries; thus unities, origins, or beginnings of three kinds; each of which is the efficient cause of the effects, and the determinant cause of the uses, of its own place, or region. The reason is, that there are so many different effects, or different uses, of one and the same body or organ. Use is what determines all things. (n. 531, *m.*) Where a moving or locomotive force is at the same time present, there we have muscular fibre, which serves as the origin of the force; where there is also a perspiration of humor, there we have glands; where there is a carrying round of this humor, or a distribution of it to contiguous membranes, or an application towards the little mouths of lymphatics, there we have concatenated cells; as around the intestines, the stomach, and most of the other viscera. But where there is regular and exquisite sense, there we have papillæ, as in almost all the chylopoietic organs. (n. 526, 527.) On the other hand, the cerebrum, the heart, the liver, the conglomerate and conglobate glands, the spleen, the pancreas, the omentum, the papillary cutis, and the muscles, are organs of single origin.

the ends of objects, and the beginnings of offices or operations, and the first efficient causes of effects, and determinant causes of uses, so far as they are uses. Thus in the *liver*, the blood that passes through the branches of the portal veins, goes no further than the hepatic glands, before it changes its character; and passes out from the glands through the veins to the branches of the vena cava, and through the hepatic pores to the ductus cysticus and ductus cholidochus (*m*). In the *spleen*, the blood runs in no deeper than the splenic cells, and after discharging itself into them, it returns again into the little venous channels (*n*). In the *lungs*, the blood of the right side of the heart digresses only as far as their retia mirabilia, or cellular trabecular ground-work, where it sounds a retreat, and returns to the heart's left chamber. The air also that passes in through the bronchial branches into the pulmonary vesicles, makes no attempt to go deeper, but turns back, and flows out again through its little windpipes into the atmosphere (*o*). In the

(*m*) The glands are the very principles of the liver. (Part I., p. 286, 287, n. 209, *y*, *z*.) The powers and forces in the liver are most multitudinous, and are the causes that excite the mass composed of them to operate. (*Ibid.*, p. 293, 294, n. 214.) The blood is conveyed from the vena portæ, and from other sources, through its vessels to these innermost glands. (*Ibid.*, p. 280, n. 206.) From these innermost or ultimate goals it runs out by three ways; namely, by the hepatic veins towards the branches of the vena cava; by the biliferous pores towards the ductus cysticus and ductus cholidochus; and by pores into surrounding cells, to be carried away towards the surface, to the little mouths of the lymphatics. (*Ibid.*, p. 284—286, n. 208, *r*, *s*, *t*.)

(*n*) This is manifest from the descriptions of the spleen by Heister, Winslow, and Malpighi. (Part I., p. 328—336, n. 235—237: see also [our description], p. 342—344, n. 242.) The spleen is simply cellular, and the blood extravasated into the cells is forced back into the veins. (*Ibid.*, p. 344, n. 243.)

(*o*) The texture of the lungs is cellular, and the cells are pervious, so that the operation of one cell may be continued to another. (Part II., p. 178, 179, n. 405, *s*.) In these cells the lungs correct the blood and the serum. (*Ibid.*, p. 174—176, *seqq.*, n. 405.) So that the function of purifying the blood is performed in the cellular structure, but the office of respiration in the vesicular; or in other words, their

cerebrum, the spirit of its fibres, lately the spirit of the blood, mounts no further than its cortical glands, and there describes the shortest gyre, and flows back through the medullary fibres, and then through the nervous fibres of the body. The same may be said of sensual modifications, which rise from the five external sensoria no higher than to the same principles, and if these will to produce actions, the modifications are sent out from them as forces, into the fibres of the muscles (*p*). Much the same circle and game is carried on in other parts. In the heart, however, in an inverse way; for the heart is the common centre of the blood-vessels, but is not a collection of a number of centres, like other parts; for the blood from all the little branches of the veins, flows into its right chamber, and is confluent there, and then after having digressed to the discriminated origins or cells of the lungs, returns to the left chamber of the heart, and is poured therefrom into the arteries and their branches (*q*). From these considerations it is evident, that unities are the centres, beginnings and ends of operations, however they are scattered about through the substance of their viscus; the position and place that they occupy, in no way interfere with this: for these centres, by their determinations, form radii, axes, and circumferences, which are generated and

pneumonic and circulatory power resides in the very centres and networks; and from them, governs all the circumferences. (*Ibid.*, p. 193—195, n. 408, *u*, *y*.)

(*p*) The cortical glands of the brain are the beginnings and ends of all the fibres. (n. 528 (*f*); n. 529, *h*, *i*.) The corporeal fibres mount thither with their aliment for the spirit of the fibres, and from these glands, as its beginnings, all the spirit emanates. (n. 509.) And the modes of sensations are carried up to them. (n. 529.) The voluntary determinations also flow from them, as will be seen in the following Parts of the Work.

(*q*) It is clear enough from anatomy alone, that there is a kind of continuity in the heart, but a discriminate character in other parts; in short, that the arterial and venous branches are confluent in the heart, as in a single centre, while elsewhere the productions are diverted to innumerable centres: likewise, that all the innermost coats of the arteries, and the outermost coats of the veins, fall and unite into one continuous coat in the heart. See above, n. 507.

constructed of mere centres; in this way, an idea of perpetuity, or of an everlasting chain, is induced upon forms; so that every point of a radius or circumference sees itself placed in some centre, and at the same time sees its associate parts, as extraneous to it, in some line, diameter, and surface determined by them (r). Thus again mutual relations themselves are determined in their fluxion to the idea of a similar form.

539. *Unities and continuations of unities are the essential determinations that construct the form of the whole, or the common form; but fibres with vessels are the essential determinations that construct the forms of the unities, or the particular forms.* To state this more clearly: unities, as above pointed out, (whether they be glands, or cells, or papillæ, or fibres of any kind, or continuations or productions from glands, that is to say, pores, ducts, emissary canals, or vessels,) by their fluxion or coördination build up the common form of their organ or body; and in this way are essential determinations. But the nervous fibres and the blood-vessels produce the forms of the unities only, as may be readily seen from the plexuses and as it were comitia of the nerves, and from the complication of the vessels, before they enter, and from their progression and ramification after they have entered (t). It is evident that mere *glands* determine

(r) This has been shewn repeatedly in both our Parts on the viscera of the body. There are perpetual centres and pivots that construct the organic forms of the body. (Part II., p. 314, 315, n. 450 (c); p. 329, 330, n. 455, *h*.)

(t) I do not know whether these points can be so clearly and satisfactorily explained as the true dignity of the subject demands; and this, by reason of the very words and names that are made use of to signify things, and applied so promiscuously. For to take a case, *fibres* are attributed not only to muscles, but also to tendons, and to all the membranes; with simply a distinction by adjective epithets; so that we have moving fibres, tendinous fibres, aponeurotic, filamentary, sinewy, membranous, aye, even cartilaginous and osseous fibres: when the fact is, that fibres properly are fibres of nerves, or fibres springing from the brains. The same may be said of *vessels*, by which name are meant not only arteries and veins, and this, properly, but also all pipes, little canals, ducts, emissaries, without distinction, whether arising from the heart, or from any other source. The lymphatics and

the common forms, from the case of the conglomerate glands, as the thymus, the parotid, the maxillary, the thyroid, the laryngeal, and others of the same class, which are nothing but heaps and congeries of glandular corpuscules. We plainly see that mere *cells* or follicles do the same, in the conglobate glands, as the mesenteric glands, their grand type, the cisterna chyli, in the sacral and iliac glands, in the spleen, and in the lungs, which are nothing but compages, sponges, and pulps, made up of the most minute cavities and strainers brought together and wound into these organic forms (*u*). Again, that the same ap-

lacteals are also termed vessels and veins. Now as the terms signifying are so few and general, and the things to be signified, so various and particular, very great obscurity cannot fail to arise, especially in apprehending ideas distinctly: as is evidenced in the passage in our text, where fibres with vessels are said to generate, not the common forms of the viscera, but only the particular forms; and yet we say soon afterwards, that the vessels of the vena portæ and hepatic vein construct the common form of the liver. As it is impossible to understand this without explanation, be it known, that the fibres that determine the very unities, are properly fibres, arising from the cerebrum and cerebellum; that is, nervous fibres; and the vessels, properly vessels, that is, vessels of the heart. But the vessels that flow in from the porta hepatis, are not properly the heart's, but the liver's, and the veins that go out from the glands of the liver, are not properly the heart's, because they commence in the liver, and proceed towards the branches of the vena cava, into which they do not flow continuously, but by oblique insertions; for there is no other gate or porta for the venous blood into the vena cava from the viscera of the abdomen, than through the liver. The same is to be understood of the pancreatic branches and veins.

(*u*) Respecting the spleen, see the description of that organ in Part I., p. 328—336, n. 235—238; and p. 342—344, n. 242. Respecting the conglobate glands, Malpighi says: "When the gland is laid open, we find rows of loculi, surrounded by areolæ of fibres, under the membrane itself.... After entering [the glands], the larger branches [of the blood-vessels] form a network, and their last twigs appear to terminate on the loculi and parietes of the areolæ." (*Ibid.*, p. 228, n. 173.) See also Nuck, *Ibid.*, p. 224—227, n. 172; Boerhaave, *Ibid.*, p. 230—233, n. 174. The lymphatic vessel is as it were a line or thread; the cellular tissue as it were an area, plane, or web of

plies to mere *papillæ*, is clear from the papillary organs, for instance, of the skin, the tongue, the nares, the œsophagus, the stomach, the intestines, the ureters, and the bladder, which have peculiar villous membranes bestowed upon them. And it is evident from the muscles and the heart, that mere *fibres*, mutually applied to each other, and disposed into a common form, in the way of the moving fibres, do the same: this is evident with respect to sinewy or tendinous fibres, from the tendons and aponeuroses; and with respect to filamentary and vascular fibres, from the common coverings, the diaphragm, the peritonæum, the pleura, the pericardium, which are at the same time cellular; and from the dura mater. But in addition to these simply begotten and uniform fabrics, there are others both more numerous and more remarkable, which at the same time that they are composed of glands, are also composed of the vessels, ducts, pores, emissaries and fibres, continued from them. Among these we may reckon the *liver*, which is not made up of glandular granules alone, but also of branches of the vena portæ, and of the hepatic veins and ducts, or pori bilarii, all of which are derived and put forth from its innermost follicles, as from their centres, or last and first boundaries, and weave the com-

similar lines or threads; and the conglobate gland, a mass, volume, or body of trine dimension. *(Ibid.,* p. 222, n. 170.) Respecting the lungs, Heister says: "The pulmonary substance . . . is entirely made up of minute vesicles of a fleshy texture, and of various vessels. These vessels are the bronchia . . . &c. . . . They [the bronchia] arise from the trachea, and dividing first into branches, then into innumerable twigs, finally terminate in the minute vesicles before mentioned. These vesicles, forming a principal part of the substance of the lungs, leave between them interstices, . . . and they seem to adhere to the little branches of the bronchia in the manner of clusters of grapes." (Part II., p. 121, n. 385.) And according to Winslow: "The substance of the lungs is almost all spongy, being made up of an infinite number of membranous cells. . . . The air-vessels make the chief part." *(Ibid.,* p. 124, n. 387.) See Malpighi especially. (*Ibid.*, p. 128—131, n. 388, 389.) Respecting the continuous ramification of the trachea through the lungs, see *Ibid.*, p. 93, n. 372. Respecting the cellular tissue of the lungs, *Ibid.* p. 178, 179, n. 405 (*s*).

mon fabric of the viscus (*x*). Likewise the *pancreas*, which is formed not merely of its glandular principles, but also of the branches of its artery, and of the pancreatic veins and little ducts, that run backwards and forwards, to the glands as their centres, and from the glands as their centres (*y*). And especially the *cerebrum*, the cortical glands of which, by their mutual apposition, conjointly form its circumference, while the fibres continued from those glands constitute its medullary globe or centrum ovale. Glands of a very similar kind, but differently arranged, together with the fibres springing from them, construct and make up the *cerebellum*, *medulla oblongata*, and *medulla spinalis*. The fibres springing from these glands as their little fountains, are the unities continued, which after being confasciculated into nerves, pass out through the foramina of the skull into the provinces of the head or of the body, and there go, not to produce as common determinations the organs or viscera themselves, but as particular determinations, to produce their unities. The fibres of the cerebrum go to produce the unities of the organs of the senses, and of the muscles at the surface of the body; but the fibres of the cerebellum,

(*x*) "The liver," says Winslow, "is composed of several kinds of vessels, the ramifications of which are multiplied in a stupendous manner, and by the intertwinement of their capillary extremities, form an innumerable quantity of friable and pulpy granules, which are looked on as so many peculiar organs, whereby a particular fluid called bile is secreted. . . . The extremities of all the ramifications [of the vena portæ] end in pulpy, friable granules. . . . In these . . . the bile is secreted, and it is immediately collected in the same number of extremities of another kind of vessels, which unite by numerous ramifications into one common trunk. These ramifications are termed pori bilarii." (Part I., p. 257, 258, n. 194.) See Heister respecting the same, *Ibid.*, p. 253—255, n. 191. The sphere of activity of the liver extends towards the vena cava, all the way to the ends of the hepatic veins. (*Ibid.*, p. 291, 292, n. 211 *k*.) Consequently towards the ductus cysticus through the pori bilarii; and to the vena portæ, through its own branches.

(*y*) This is agreeable to the descriptions and plates of the pancreas; (see Part I., p. 306—309, n. 219—224;) and is evident from a comparison of the pancreas with the liver.

the unities of the viscera, planes and canals within this surface and mail (z). The same may be said of the vessels, that is, of the arteries brought from the heart as their common centre; these unite with the fibres of the two brains, and complete the forms of the unities. Thus the fibres with the vessels infuse into them their very *posse* and *esse*, or potency and essence: and therewith the ground that makes them into particular causes; and insinuate into the forms of the unities the very end for which the effects exist (n. 538).

540. *The little canals and the branches that flow into the least glands as into their centres, make their end and last boundary therein; but those that flow out from them, as from their centres, make their beginning or first boundary therein. The former are the active forces of their body; the latter, the passive forces; which two kinds of forces in conjunction generate and produce the organic fabric.* Let us again proceed in our analytic way, already laid down by our investigations of the viscera of the abdomen and thorax; and thus keep the torch in our hands. We have long ago been taught by this method, that the organic forms or fabrics, which are as many in number as the members and parts of the body, arising from glandular beginnings, or from corpuscules analogous to glands, or even from cells, generate their own vessels; of which there are some that flow in, and some that flow out. This is the case on the greatest scale with the *heart;* for the veins, which are of a passive character, go with their sanguineous stream to its right auricle and chamber, and the arteries, which are of an active character, issue from its left chamber (a). And the same thing is observable in the other organic fabrics, where there is not one heart, but a number of as it were little hearts, or centres of circulations, as in the members before mentioned (n. 538); in which respects the liver, the lungs, and the brain stand preëminent, and afford the most remarkable examples. In the *liver* there are branches, that running from its two gates penetrate with blood towards

(z) See above, n. 527 (a).

(a) That the veins are of a passive character, but the arteries, of an active character, was shewn by many considerations in my *Economy of the Animal Kingdom,* tr. i., n. 190—198, 231—233.

its innermost chambers or follicles: there are moreover two kinds of vessels that flow out from the same multiplied corcula. The vessels of the first kind are the hepatic veins; these carry away with them the blood impregnated with fresh chyle, and convey it until they meet the branches of the vena cava. The vessels of the second kind are the biliary or hepatic pores, which carry out the dregs that are yet to be purified, and convey them all the way into the ductus cysticus and ductus cholidochus, that they may be given up to be treated by the intestines (*b*). The little canals and the branches that flow in, are the active and male [*maritæ*] forces of that viscus, and are analogous to the arteries of the heart; but those that flow out are its passive and as it were female [*uxoriæ*] forces, and are analogous to veins in character (*c*): exactly the reverse in method and plan to what we see in the heart; for in the liver, the influent branches grow finer and finer, and more and more multiple, as they proceed to these discriminated corcula or centres; but the effluent branches, the contrary: while those that flow into the

(*b*) See just above, n. 539, and note (*x*).

(*c*) "The vessel," says Winslow, "which carries the blood to the liver is called vena portæ. This vein may be considered as two large veins. . . . At this place [the sinus of the vena portæ], the vena portæ lays aside the office of a vein, and becomes a kind of artery, as it enters and circumramifies in the liver. The extremities of all its ramifications end in pulpy, friable granules, which when examined through a microscope in clear water, seem to be thick villous follicles," &c. (Part I., p. 258, n. 194.) To these [ramifications] correspond vessels of another kind, of which those that carry away the blood from the follicles towards the branches of the vena cava, are termed hepatic veins; but the others, pori bilarii; and which originating as they do from the same follicle, cannot fail to be of a venous nature. It is the nature of veins, that the fluid running through them suffers itself to be acted upon by its vessel, or by the coats of its vessel; but it is the nature of arteries, that the vessel or coat suffers itself to be acted upon by its fluid, and that the coat in like manner reacts. That such is the condition of the arteries of the body, see my *Economy of the Animal Kingdom*, tr. i., n. 166—189; and of the veins, *Ibid.*, n. 190—198. Respecting the vessels of the liver, and their function, see Part I., p. 284—286, n. 208.

chamber of the heart, as into a single, continuous, and common centre, increase in diameter and bulk, but those that flow from it, decrease. The same principle is represented in the *lungs:* the pulmonary artery flows in with all the blood of its heart, and never stops until it has split into the minutest ramifications in the reticulated centres of the cells: and again collecting therein into a comparatively small number of branches, it pours itself back as a vein, with all its blood, into the left cavities of the heart; shewing that here also, as in the liver, the vessels run out to their last goals, and changing their character in the innermost receptacles, again return to a point near their former starting-place (*d*). The same process is carried on in the *brains:* a perpetual river of the purest aliment flows from the cutaneous pores into the high forms of the cerebral glands, or the spherules of the cortical substance, which are so many first and last boundaries of the fibres; and a most refined essence termed the animal spirit is generated from this aliment in the laboratories of these glands (*e*): this spirit, like the blood and chyle in the

(*d*) "[The cellular substance]," says Winslow, "is dispersed through every part of the lungs, and forms cellular or spongy sheaths which surround the ramifications of the bronchia, . . . and is afterwards spread over the outer surface of each lung, where it forms a kind of fine cellular coat. . . . All the bronchial cells [or vesicles] are surrounded by a very fine reticular texture, consisting of the small extremities of arteries and veins which communicate every way with each other," &c. (Part II., p. 125, n. 387.) Respecting this Malpighian network, see Malpighi himself, *Ibid.*, p. 129, n. 388. How the blood flowing in through the pulmonary artery from the right ventricle of the heart, penetrates all the way to these networks, and is purified there. (*Ibid.*, p. 174—182, n. 405; p. 186, n. 406; p. 191, 192, n. 407.) On account of the venous blood that the pulmonary artery carries from the heart, it would seem that it should be called a vein; yet again since it has one distinguishing mark of an artery, in that it diminishes in calibre, and increases in the number of its ramifications, in the direction of the sanguineous current, and in its ultimate capillaries separates and excretes various essences from the blood, therefore it would appear that it may deservedly and *ex officio* be termed an artery. (*Ibid.*, p. 193, n. 407.) The bronchial artery teaches the pulmonary to play the artery. (*Ibid.*, p. 203, 204, n. 409, *q.*)

(*e*) The subtlest pores generated by the cutaneous fibres, and drawn

liver, is sent out by two ways, or through fibres of two different characters and functions; to wit, through sensorial and motorial fibres; through the former, to the sensorial organs of the head and the body; through the latter, to the motorial organs, or the muscles. The one and the other, as first parents, build and furnish all the forms of the organic body from the innermost: the sensorial fibres, as forces eminently passive, carry up the impressed modes of objects to the cerebrum; while the motorial fibres, as forces eminently active, carry down the voluntary modes to the muscles of the body. Thus the same order prevails everywhere, and the same wonderful consent in generals. It is, then, a common and perpetual law in all the organic fabrics of the body, *that determinations and fluxions proceed from the outermost sphere to the innermost, and from the innermost to the outermost; or what amounts to the same thing, from the greatest to the least, and from the least to the greatest, or from compounds to simples, and from simples to compounds* (*f*).

541. *The proper vessels of the organs and viscera, that go out from them, bear in every point of them exactly the same character and nature as the unities from which they are produced; and carry out with them, wherever they go, this character and nature received from their unities, as principles; so that they are the unities con-*

back from their apertures, produce fibres that are to be called corporeal fibres. (n. 504.) These pores* convey the elemental food that they sip from the ether and celestial auras, immediately to the cortical glands of the brain, which are the prime laboratories of the spirits. (n. 507, 509.)

(*f*) The vessels, like all other things in the visible world, in each of their degrees, have their determinate maximum and minimum, and proceed from their maximum to their minimum, and from their minimum to their maximum. (*Economy of the Animal Kingdom*, tr. i., n. 156—163.) By intimates, leasts, and simples, we understand the unities above described; but not the least, simple, and innermost things that enter and construct the unities themselves; that is to say, not the nervous fibres and vessels; according to what we observed above, n. 538, 539.

* It is to be observed, that the word *pore*, in anatomical language, means frequently a channel or passage, and that its signification is not limited to holes or outlets merely.—(*Tr.*)

tinued. But the proper vessels that enter the organs and viscera, and terminate in the unities as centres, take the character and nature at once of the compound and the unity; thus again the same, because compounds and unities, as similar types, resemble each other in their manner of operation; or mutually represent each other. This law also holds good of the same organs that we have before submitted to analytic scrutiny; particularly of those illustrious organs that are the heads of the families of the body; I mean, the heart, the liver, the lungs, and the cerebrum: all the other organs take the same course, and side with these. Here again, then, let us listen to the oracle of experience. All the innumerable arteries of the one *heart,* that is to say, all the possible arteries of the body, in their running forth, carry no other motion or manner of action than what they owe to their heart, and this they keep as it were inscribed upon their fibres, little circles, and membranes, all the way to the end. The vessels are only discriminated quantities, or multitude, while the heart is a continuous quantity, or magnitude, that describes and distributes itself into the vessels. The very membranes of the heart are continued uninterruptedly to the aorta, and from the aorta to its whole offspring, as the bark of a tree is continued to the branches and twigs; the innermost coat produces itself all the way to the extremities (*g*). The blood runs through the same vessels in a continuous stream, and as it is impelled in the heart, so it is impelled in the arteries; the same kind of pulse that is impressed in the first sphere is also actively present in the last; nay, the same kind that is impressed in any point of one of the higher branches, is also present in the branches succeeding it; so that when the systole of the centre ceases, the systole of the branch instantly ceases also; or when the pulse of the branch ceases, the pulse of its continuous ramifications ceases also (*h*). Thus, wherever any little artery is

(*g*) We have ocular proof of the fact, that the muscle of the heart is continued to the muscular coat of the great artery, and so forth: and while this coat becomes progressively thinner, and at last is taken off and vanishes, the innermost coat remains to the very ends of the arteries, as shewn above, n. 507—509.

(*h*) This was proved by many considerations in the *Economy of the*

present, there the heart itself is as it were presented, and acts. Very similar is the case in the *liver:* its proper vein and biliary pore are encircled with the same little coat produced from the common coat, as the central follicle itself, or the little heart or corculum termed a hepatic gland (*i*). The fibre of the same

Animal Kingdom, where the following conclusion was the result to which we came: "In the doctrine of muscle, artery, and fibre, this rule has the first and last place, that in every point of an artery there is a certain likeness of the heart, and in every point of a fibre there is a certain likeness of the brain; namely, in this way, that there is no point in an artery, and no point in a fibre, that does not propel its fluid, just as if the beginning, to wit, the heart, or the brain, were absolutely present there: wherefore, when any point of a vessel or fibre is touched, compressed, distended, or otherwise modified, a similar modification instantly runs along all the vessels that come after that point, or along all the fibres, down to the extremities; with this difference only, that such a touch modifies but a few fibres, namely, those that follow [the part touched], while the cerebrum and cerebellum modify all universally, as the heart modifies all the arteries." (*Op. Cit.*, tr. i., n. 507, 570.) And hence the correspondence of the heart with the ramifications in all the peripherics and extremes. (*Ibid.*, n. 234.)

(*i*) The production of the capsule is wonderful, and is not easily comprehended by an intuitive idea alone; for it is continued from the common coat of the viscus, and envelops the vena portæ, all the proper vessels of the liver, as the branches of the vena portæ, the hepatic vein and porus bilarius, also the common vessels, as the hepatic artery, and the nerves, and proceeds with the whole bundle of them towards the glands, which are again surrounded one by one with a production of the same capsule. So that by this which is called the capsule of Glisson, there is a continuation of the innermost things with the outermost, or a consociation of all parts. And furthermore each part is covered singly by the same. And the like takes place not only in the liver, but also in the lungs, in the spleen, and in the kidneys. In fact, if we duly examine the pericardium, and its connexion with the heart and its proper and common vessels, we see that there is a similar capsule, and that the same thing goes on there. But it would be tedious to explain all these points now; the reader will find them explained throughout in Parts I. and II., where we have treated of the above viscera. He will also find it stated, that the operations of the liver begin in its glands, and continue the same through the branches that proceed from those glands. (Part I., p. 286—290, n. 209.)

nerve, and the vessel from the same branch, that flows into the principle or gland, also flows into the vein and pore continued from them, and thus introduces a similar character, implants a similar power of acting, a similar manner of effecting, and end of operating. For the hepatic artery, and the fibre of the intercostal nerve and par vagum, which construct the innermost forms, incessantly accompany the proper vessels of the liver, and as they initiate and govern the very origin, so they initiate and govern its propagations also. This is clearly discoverable by sight (*k*); and moreover from the form of continued operation; for we everywhere find a continuous cause, or a continuous effect of the cause. And the branches of the vena portæ, which flow in, are covered throughout their course with the same capsule as the porta itself, all the way to the innermost stations; and on a signal given by the vena portæ, and at the same time by the centres, where their last boundaries are situated, they rush into obedience to both; for the circumstance that the vena portæ, or if you please, the whole composition of the liver, institutes a motion in accordance with [the motion of] all the unities or glands, results from that fabric [of the organ], by means of which one thing is placed in such close connexion with another by sheaths and tunics: for parts and compounds are so bound by bonds to the common service, that they live in a harmonious division of labor (n. 534). Organic forms are perfect, in proportion as their unities and compounds stand related to a similar type in their power and manner of acting (n. 536). Unities and continuations of unities are the essential determinations that construct the form of the whole, or the common form (n. 539). From which it follows, that the vessels that flow in, import the same nature as those that flow out export; but those vessels that enter the organ, in an inverse way to those that leave it; for the unities concur with the compounds to carry the former inwards, but the compounds concur with the unities to carry the latter outwards. The diameters

(*k*) These are mere teachings of experience; as also that the nerves proceed within the same sheath as the proper vessels of the liver, and constantly give fibres to them; likewise the hepatic artery: which fibres and vessels do everything in the very glands, as centres, that they do in the continued branches.

and peripheries of the *lungs* depend in a similar manner upon the active forces possessed by the centres; so do the least bronchial branches depend upon the vesicles; the larger branches upon the lesser; lastly, the trachea upon the larger: from which series it results, that the least vesicle is all [in all] in the lungs and tracheæ; as we have clear sensible demonstration, not only from the continuity of the parts, but also from effects, as from the intervals in sounds, and the pauses or divisions in speech. Equally compliant are the arterial and venous branches, to the innermost cells and networks of the lungs, upon which cells and networks, as upon so many centres, all the peripheries, (which are moreover formed of the very centres,) depend (*l*). The same law obtains still more perfectly in the *cerebrum:* its fibre draws forth from its principle, the cortical spherule, whatever lies in that spherule, and is engrafted upon it; for by that principle it is clothed, and by that principle it is filled with spirit; consequently, it derives from it all its power as a cause, and all its distinctive character, and this, so consentaneously, that nothing can happen to the fibre of the sensorium, whether it be of the eye, or of the ear, or of the tongue, without a most accurate likeness of it being exhibited in the sensorium of the cerebrum; that is, in the cortical substance thereof: nor can anything be turned over in the mind, that if it please may not be portrayed in the extremes by means of the fibres; for instance, in action, by the muscles. Nay, the very minds and inclinations, or affections, that excite the principles, shine out upon the face of actions, and gleam through, however they are concealed: shewing that the fibre is the cerebrum continued, or

(*l*) The reader will find this confirmed throughout in the foregoing pages, n. 532—541. Respecting the excitation of the lungs by their vesicles, to the different species of respiration, and to the various modes of speech and singing, see Part II., p. 141—144, n. 394 (?). The pneumonic power, and the circulatory power that propels the blood, resides in the very centres, cells, and networks of the lungs; and all the circumferences are governed therefrom. (*Ibid.*, p. 152, 153, n. 396 (?); p. 193—195, n. 408, *u*, *y*.) The action of the muscles of the thorax penetrates to the innermost parts of the lungs. (*Ibid.*, p. 227, n. 421, *h*.)

its cortical substance continued, and as it were a ray, in every point of which a likeness of the action of the cerebrum is most presently represented (*m*). In these respects, the other organs and viscera of the body exactly agree, whether they consist of a discriminated, or of a continuous unity: or to speak more plainly, whether their unity be a gland, or a cell, or any kind of fibre (*n*); for in all, there is a continuation of the unity. These considerations present us moreover with the following consequence; namely, *that compounds are only aggregates of simple substances, or sums of their unities put together upon the model of use.*

542. *In the organic fabrics of the body, the series in the progression of causes appears throughout to be as follows: the object or material out of which and by means of which [the effect is produced], comes from without; it is immediately carried away by distinct paths towards the centres; and at the same time is collected in a receptacle, that the centres may constantly supply their necessities therefrom. This material is examined and prepared on the way to the centres; it is then received, turned about, digested, and discriminated into parts, by the centres; the finer portion is chosen out, and sent forth for use; the viler portion is separated or secreted, sent away, corrected on the way as in the centres; and is expended upon some middle use; lastly, the residue, which is worthless, is thrown out. This is the ratio of all composition.* But without preface let us examine the fabrics themselves, which are living examples of the truth of the matter, and demonstrate

(*m*) The cortical spherules are prefixed as little hearts to each fibre. (*Econ. A. K.*, tr. i., n. 177, 472; tr. ii., n. 111—117, n. 132—147.) There is a likeness of the brain in every fibre. (*Ibid.*, tr. i,, n. 507, 570.) The fibres carry with them the animus of the brain, and exercise desire and loathing, and thus choose out and absorb a suitable chyle. (*Animal Kingdom*, Part I., p. 206, 207, n. 156 (*h, i, k*); p. 207, 208, n. 157 (*l*); p. 242, n. 185.) Without such harmony of the extremes, no possible concord could exist in the body; so that without there were a kind of cerebrum, by the likeness of its action, present in every fibre, and a heart likewise, in every vessel, we should look in vain for any effect.

(*n*) Glands, cells, papillæ, or some kind of fibres, are the common unities of the viscera and organs of the body (n. 538).

it to us; to wit, the liver, the lungs, the stomach, the heart, and lastly the cerebrum and the organs of the senses. And first, with respect to the LIVER; its office is, to refine the chyle, to marry it to the blood, and to lustrate the blood itself (*o*). In this case, *the object or material out of which* [*the effect is produced*], or the blood mingled with the fresh chyle, *comes from without*, namely, from the stomach, the intestines, the mesentery, and the omentum; and the blood that is to be lustrated, and at the same time to serve as a menstruum, comes from the pancreas and the spleen; as well as immediately from the aorta or the cœliac artery; all of which are extrinsic to the liver. This blood *is immediately carried away by distinct paths towards the centres* (*p*) through the hepatic artery, which freely anastomosing with the vessels of the liver, carries in the blood by a short cut (*q*). *And at the same time is collected in a receptacle,*

(*o*) The liver is the defecatory of the chyle, the lustratory of the blood, and the preparatory of the hepatic bile. (Part. I., p. 277, 278, n. 204, *d, e.*)

(*p*) The liver receives the crude chyle from the stomach and intestines by way of the veins. (Part I., p. 278, n. 205.) It receives the impure blood from the spleen and the pancreas. (*Ibid.*, p. 278, 279, n. 205.) In order to purify the chyle and inaugurate it into the blood, the liver has need of a menstruum prepared by the spleen and the pancreas. (*Ibid.*, p. 355, 356, n. 246 (*l*); p. 358, n. 247; p. 347, n. 244.) The liver demands back the embodiment of the blood from the omentum particularly. (*Ibid.*, p. 390, 391, n. 265.) It is well known that the blood of the mesentery also is conveyed towards the liver.

(*q*) The hepatic artery pours on new blood. (Part I., p. 284, n. 208, *r.*) This hepatic artery arises from the cœliac artery or from the aorta, and proceeds along with the branches of the vena portæ within the capsule of Glisson; frequently communicating with those branches, just as the bronchial artery in the lungs frequently communicates with the branches of the pulmonary artery. "The liver receives from the cœliac artery," says Winslow, "a peculiar . . . branch called the hepatic artery. . . . The ramifications of the hepatic artery and nervous plexus, are enclosed in the cellular capsule, together with the branches of the vena portæ, and the pori bilarii. . . . If we blow through a tube into the vena portæ, vena cava, hepatic artery, or trunk of the pori bilarii, but especially into the veins, the mass of the liver imme-

or in the two-fold vena portæ, *from which the centres supply their necessities* (r). The blood taken out therefrom, and thoroughly kneaded there, *is examined, and prepared on the way towards the glands;* for the part that is serous, and infarcted with crudities, and that would hinder separation in the centres, is cast aside through the foramina with which the vessels of the vena portæ are perforated, into the surrounding cellular tissue, and by that tissue is carried off all the way towards the surface, where again it is exposed to the little mouths of the lymphatics and veins, which pick out and collect the finer portions of it (s). *It is then received by the centres, and turned about* by the alternate expansion and constriction of each centre or gland, which movements are synchronous with the respiratory movements of

diately begins to swell, and the granules next the surface are raised, and become more perceptible." *(Ibid.,* p. 258, 259, n. 194.) See also the other authors there quoted, and what is said below of the bronchial artery [n. 543], which serves the same purpose in the lungs as the hepatic artery in the liver.

(r) The vena portæ is the receptacle of the blood conveyed thither by the stomach, intestines, omentum, pancreas and spleen; and confounds all their streams into as it were one chaos. (Part I., p. 278, 279, n. 205, *g, h, i, k.*) And the internal parts of the liver can summon from it, as from a storehouse, the whole supply, so that the laboratory of the organ may never lie unemployed.

(s) The branches of the capsule of the liver are perspirable throughout. *(Ibid.,* p. 289, 290, n. 209, *g.*) And the glands, as well as the branches, are perforated with holes, from which the lymph exudes. *(Ibid.,* p. 285, n. 208, *s.*) This is evident from the surrounding cellular tissue; from the exudation and transmission of the lymph towards the surface, where innumerable lymphatics are conspicuous: it is shewn especially by the anatomy of other viscera compared with that of the liver, as the lungs, the spleen, the kidneys, the biliary capsules [or succenturiate kidneys], &c., the branches and pipes of which are full of perforations. Thus anything that would hinder separation in the innermost glands, is carried away. The lymphatics demand back the spirituous parts and valuable essences of things, and restore them to the blood. *(Ibid.,* p. 448—450, n. 291 (*m*), n. 292.) But the veins demand back the embodiment of the blood. *(Ibid.,* p. 447, 448, n. 291.)

the lungs (*t*). Consequently, ***it is discriminated into parts*** and separated; that is to say, the clean and defecated portion, or the blood mingled and married with the virgin chyle, is taken into the hepatic veins, which export it through their branches until they meet those of the vena cava (*u*). ***Thus the finer portion is chosen out, and sent forth for use.*** But the unclean and outcast portion, or the bile, is poured into the hepatic pores, and therein, as in the centres themselves, or in the glands, of which these pores are continuations, it is turned about, digested, and divided, and this goes on all the way to the ductus cysticus, and afterwards through the ductus cholidochus, and even in the intestines (*x*). ***Thus the viler portion is separated, and corrected on the way as in the centres,*** and at the same time is of this use, that it serves as a menstruum to both the intestines and the gall-bladder (*y*): and in this way ***is expended upon a middle use.***

(*t*) In the liver all things are done by virtue of expansion and constriction. (*Ibid.*, p. 285, 286, n. 208, *u*.) These motions are synchronous with the respirations of the lungs. (*Ibid.*, p. 294, n. 214, *q*.)

(*u*) The hepatic vein carries away the blood mixed with chyle, and transfers it into the vena cava. (*Ibid.*, p. 291, n. 211.) The liver's sphere of activity extends towards the vena cava, all the way to the ends of the branches of the hepatic vein. (*Ibid.*, p. 291, 292, n. 211, *k*.)

(*x*) The proper vessels of the viscera, that go out from them, possess in every point of them exactly the same character and nature as the unities from which they are produced; and wherever they go, retain this character and nature received from their unities, as principles, and carry it out with them; so that they are the unities continued (n. 541). The offices commenced in the glands, continue to be of the same character through the whole of the biliferous passage, so that the liver is at work in every point, separating, discriminating, and purifying the chyle and the blood. (Part I., p. 287—290, n. 209.) The porus bilarius corrects and purifies both the chyle and the blood. (*Ibid.*, p. 290, 291, n. 210, *h*, *i*.) The porus bilarius, as well as the hepatic duct, works the bile, as the intestines work the food. (*Ibid.*, p. 293, n. 213, *n*.) This working or treatment of the bile never ceases. (*Ibid.*, p. 303, 304, n. 218, *g*.)

(*y*) It is well known that the pori bilarii unite to form the hepatic duct, and that the hepatic bile is poured into the intestines together with the cystic and pancreatic biles: it is also a common opinion, that

But the part that is quite effete is rejected with the alvine fæces (z); *so lastly, the residue, which is worthless, is thrown out.* The liver is formed for this series of operations, or of progression of causes, this being *the ratio of its composition.*

543. Secondly, the same plan is carried out in the LUNGS, the offices of which consist in respiring, or rousing the organs of the body to their tasks by means of respiration (*a*); also in purifying the blood; but let us consider the progression of the one office separately from that of the other. With respect to the first office, or respiration, we all know, that *the air is the object or material by means of which* [*respiration is carried on*]; and that *it comes from without,* or through the nares, the labial mouth, the palate, the larynx, and the trachea; and *is carried away by distinct paths,* that is, by the bronchial branches, *towards the centres* of the lungs, or the vesicles (*b*): *and at the same time is collected* in the trachea as *in a receptacle, that the* vesicles or *centres may supply their necessities therefrom.* It is evident that the trachea is a receptacle, from the power that we possess of respiring for some time even with the mouth and nares stopped up (*c*). *The air is examined and prepared on the*

these biles, or their admixture, serve as a gross salivary humor to assist the intestines to digest, and the food, to be digested. The bile is not absolutely rejected, but the genuine portion of it returns into the blood. (*Ibid.*, p. 304, 305, n. 218, *h.*) The hepatic bile returns with interest. (*Ibid.*, p. 293, n. 213, *n.*) The liver rejects the hard blood into the gall-bladder, in order to be treated, and at the same time to serve as a menstruum. (*Ibid*, p. 296—300, n. 215.)

(*z*) None but the dead portion of the bile is rejected with the alvine fæces. (*Ibid.*, p. 304, 305, n. 218.)

(*a*) The common use of the lungs consists in respiring. (Part II., p. 141, n. 393, 394.) And in exciting the viscera to their functions. (*Ibid.*, p. 140, n. 392; p. 150—172, n. 395—403.)

(*b*) The lungs are the continued ramification of the trachea, and the air penetrates all the way to the vesicles, as to the ultimate boundaries, or as to the centres, where the lungs especially exercise their pneumonic function. (Part II., p. 93, n. 372; p. 141—145, n. 394.)

(*c*) It may be concluded, that the trachea and the bronchia are receptacles of the air, not only from the capacity and from the fabric of both, in that they admit of being considerably expanded and constricted

way to the centres, so that when it flows in, it may not be biting, rough, and cold, but tepid and exactly accommodated to the effects that are to be produced (*d*). *It is then received by the centres, turned about and digested* by continual volution, collision, and repercussion, when it is to be inaugurated into the production of sound, as well as by the expansions and constrictions proper to the lungs (*e*); *it is discriminated into parts;* then the quality and quantity that is suitable, *is chosen out* by the vesicles of this or that region, and *sent forth for use* to the larynx, to produce speech or song (*f*). But the part that is not suitable, *is separated*, and expired during the intervals of the

by means of their cartilaginous circles, and their lamellæ placed one beside another, (See Part II., p. 145, 146, n. 394, *h*:) but also from an experiment that every one may try in his own person, by stopping up the nostrils and the mouth; as Mayow, Verheyen, Plempius, and others, state from their own observation. "I can raise and depress my chest," says Plempius, "when the larynx is closed, in the same way as when I respire," &c. (Verheyen, *Suppl. Corp. Hum. Anat.*, lib. ii., tract. ii., cap. vi.)

(*d*) The nares temper with a gentle warmth the air which is entering. (Part II., p. 12, n. 344.) They cleanse and purify it from floating particles of dust, and noxious exhalations. (*Ibid.*, p. 14, n. 344.) The trachea does the like. (*Ibid.*, p. 95, n. 374; p. 99—101, n. 375.) And the lungs also. (*Ibid.*, p. 185, 186, n. 406.)

(*e*) The pneumonic power of the lungs resides in their very centres or vesicles, and governs all the circumferences therefrom. (Part II., p. 193—195, n. 408, *u*, *y*.) How inspiration and expiration are performed. (*Ibid.*, p. 141—148, n. 394.) How the lungs concur with the trachea and the larynx to produce sounds; namely, that it is done by the mere repercussion of the air, this repercussion being continued from the vesicles through the bronchial branches and the trachea: and the action of the lungs upon the air during breathing, is different from the action during sounding and modulating. (*Ibid.*, p. 64, 65, n. 364; p. 70, 71, n. 365 (*a*); p. 102, n. 376 (*n*); p. 105, n. 378 (*x*); p. 168—172, n. 403.)

(*f*) We have there also explained how the muscles act upon the diaphragm, and this upon the lungs, at one time upon one part of them, at another time upon another part; thus mediately upon the vesicles themselves, so that the air, after undergoing repercussion within, is extruded. (*Ibid.*, p. 169—172, n. 403.)

other action, and thus *is sent away,* and on the way to generate and promote the sound, or the sonorous ground of speech, in like manner as in the centres, it undergoes volution, collision, and repercussion; thus it is in a manner *corrected, and expended upon a middle use* (*g*): what is left, and will serve the office of speech no longer, is *expired;* thus *the residue is thrown out.* But this office of the lungs, namely, their respiratory in conjunction with their locutory office, does not shew this progression of causes so clearly, as the other office associated with it, of recruiting the blood, which is carried on by the mediation of the air. The air as *the object or material by means of which* [*the effect is produced*], *comes from without, and is carried away by distinct paths towards the centres, and at the same time is collected in a receptacle, that the centres may supply their necessities therefrom* (*h*): for the air, filled and impregnated with aërial effluvia and aliments, and gliding in through the nares and the trachea, *is* sedulously *purified* of noxious and recrementitious matters *on the way to the centres,* and is so well *prepared,* that when it reaches the innermost parts, or the vesicles, it is pure and clear, and carries nothing but vapors friendly to the blood (*i*).

(*g*) The trachea produces the rude sound, which the larynx forms into singing and speech; and this, by the impulsion [of the air] upon its membranes. (*Ibid.*, p. 104, 105, n. 378.)

(*h*) Or as explained just above, and here again brought forward: "the air is the *object or material by means of which* [*respiration is carried on*]; and it *comes from without,* or through the nares, the labial mouth, the palate, the larynx, and the trachea; and *is carried away by distinct paths,* that is, by the bronchial branches, *towards the centres* of the lungs, or the vesicles (*b*): *and at the same time is collected* in the trachea as *in a receptacle, that the* vesicles or *centres may supply their necessities therefrom.*" That the trachea is a receptacle, see note (*c*).

(*i*) The air attracted into the lungs carries with it volatile matters, by which the blood is nourished as it were with heavenly food. (Part II., p. 183—187, n. 406, *h.*) The nares cleanse and purify this air from floating particles of dust, and noxious exhalations. (*Ibid.*, p. 14, n. 344.) The trachea does the like, and prevents anything hurtful from entering. (*Ibid.*, p. 99—101, n. 375.) And the lungs are the colatories and lustratories of the air, and the refectories of the blood,

The air, with these its gifts and aliments, *is received by the centres, turned about, and* as it were *digested;* then these aliments *are discriminated,* so that those that are suitable are seized by the veins, and carried away to the left chamber of the heart. *Thus the finer portion is chosen out, and sent forth for use* (*k*). But *the rest is separated and sent away,* namely, through the foramina with which the bronchia are perforated, into the cellular tissue (*l*), where *it is corrected, as in the centres,* by processes of working and turning, continual and alternate, and as it were of digestion (*m*); and there the refined and better portion separated from the viler is absorbed by the little mouths of the veins, and on the surface by the lymphatics (*n*); and at once

as stated in the following words: "Thus the air, closely examined at every corner of the way, and emunged of its impure accompaniments, at length comes to the lungs in their smallest form, namely, to the vesicles, and now warm and bathed in vapors, it has nothing in its bosom but what is friendly to the blood,—nothing but delicate and welcome presents, which the veins, omnipresent in their little atmospheric world of the vesicle, and hungry after all their losses, must eagerly seek out, select and imbibe." (*Ibid.*, p. 186, n. 406. See also p. 191, 192, n. 407.)

(*k*) The lungs recruit the blood, and purify its serum, and how. (Part II., p. 174 *seqq.*, n. 405 *seqq.*, and notes.) The veins and lymphatics absorb and carry back the finer matters. (*Ibid.*, p. 176, 177, n. 405.) The air insinuates aërial aliment into the blood, and the lungs in this way are refectories of the blood. (*Ibid.*, p. 184—186, n. 406 (*d*) *ad fin.* The veins imbibe these presents or aliments, and carry them away. (*Ibid.*, p. 184, n. 406.)

(*l*) The bronchia are perforated with numberless little foramina, through which not the air, but the elemental and alimentitious particles brought by the air, are extruded into the cellular tissue; proved by experimental evidence. (Part II., p. 179—181, n. 405, *u*, *x*.)

(*m*) How the cells of the interlobular texture are kept in perpetual expansion and constriction while the lungs are respiring. (Part II., p. 195—197, n. 408, *z*.) So that the working and castigation of the humor carried in, is continual and not alternate.

(*n*) In order to exhibit a little more clearly the mode in which the blood is lustrated by means of the air, I will here set forth the process as described, and illustrated by anatomical facts and observations, in a former part of this Work. The passage to which I allude is as follows:

serves as a vehicle for throwing out the serum of the blood into that cellular or spongy tissue, and as a menstruum for it after it has been thrown out, in order that it in like manner may be digested; *thus it is expended upon a middle use* (*o*). But the remaining part, being *caput mortuum* and nothing worth, is sent

"Whatever is sanguineous, or kindred thereto and consanguineous, they [the lungs] transmit into continuous veins; but whatever is discordant and heterogeneous, whatever is merely a dead weight and a useless burden, hostile to the marriage of the chyle with the spirit, and windy or flatulent, they expunge and banish out of the bronchial and vesicular lobules into the cells of the interstices, and there work and knead by reciprocal powers of constriction, and express its liquid from its thicker parts. But the lungs do not throw out the whole of this impure humor, for the veins select and reabsorb the part available for the blood; the lymphatics imbibe the spirituous part, when sublimed to the surface, while the cellular tissue carries off the spume that is left, and extrudes it through foramina, leading uninterruptedly from the vesicles to the larynx, into the bronchia and trachea. Thus the lungs clear away the dross and impurities of the blood, and purify and correct the undigested contents of the heart, divided, according to nature's wonted manner, into their individual parts." (Part II., p. 176, 177, n. 405.) The reader will find these statements confirmed by a number of considerations, in *Ibid.*, p. 174—183, n. 405, and the notes.

(*o*) I omitted to state in the Analysis of the Lungs, that the humor in the ever-moistened cells serves as a vehicle for introducing the serum of the blood that is to be purified so as to form a menstruum; but that this humor does perform the *office of a vehicle* may be concluded from many considerations. For the cellular tissue is like a sponge, and is therefore called by anatomists the spongy tissue; and as it is moist, fluid rises into it continually, and as it were spontaneously, by a law of nature; just as into other porous bodies that have previously been moistened, particularly into the pores of vegetables: so that one supply of humor makes and opens the way for another. That it also serves *as a menstruum*, in the same manner as the humor doomed to rejection of the liver and pancreas, and of the gall-bladder, in the intestines, may be gathered from its mediate nature, in that it still possesses parts of a comparatively fine and valuable kind, which admit of being gathered together and associated with their likes. We have no room here to support these declarations by experimental proofs.

off into the bronchia and trachea, from which it is excreted both in the form of sputa, and by the air itself, that impregnated with effete vapors, carries out this dead remainder; *thus the residue, which is worthless, is thrown out* (*p*). But let us dwell a little longer upon the purificatory process that the blood undergoes in the lungs: for the second office proper to the lungs consists in purifying all the blood of the body, which being conveyed into the right ventricle of the heart, during every systolic action thereof is poured into the lungs through the pulmonary artery. This process is carried on in the very cells and networks of the lungs. Whatever the air carries in with it from the atmosphere, it presents to the blood as a kind of celestial gift, not in order that the blood may be purified, but in order that it may be exalted to a higher dignity, and become like arterial blood (*q*): wherefore let us as heretofore consider this second function of the lungs in relation to the same general idea. In this case, not the air but the blood itself is *the object or material* which is to be purified, and which flows in through the pulmonary artery from the right ventricle of the heart with the fresh chyle; thus it *comes from without*. This blood *is immediately carried away by distinct paths towards the centres*; that is to say, by the branches and twigs of the bronchial artery, which flows in towards those ultimate boundaries from the great artery or from one of the intercostals, and which is immediately

(*p*) The lungs impregnate with vapors the air that is passing out, and load it with effete exhalations. (Part II., p. 101, n. 375.) They perform the office of emunctories. (*Ibid.*, p. 186, n. 406.) And in these words: "As soon as ever they [the lungs] have enjoyed the banquet, they throw out the air as the most deadly enemy of the blood, and . . . load it like a mule with a baggage and burden of adulterations, and force it to carry them out." (*Ibid.*, p. 184, 185, n. 406.) The trachea lends assistance to the lungs in these respects. (*Ibid.*, p. 101, 102, n. 376.)

(*q*) This is described and shewn in Part II., as follows: "Thus the blood, fed and feasted with occult, ethereal, and heavenly food, and no longer turbid and cloudy, but serene, florid, purple, joyous, lively, and worthy of marriage with the spirit, has already put on the arterial robe." (*Ibid.*, p. 186, n. 406.)

carried away thither [to the centres] (*r*): so likewise is the great pulmonary artery, towards the plexiform networks and cells as its ultimate stations (*s*). This object, or this blood, *is at the*

(*r*) See the description of the bronchial artery by Ruysch, [*Dilucid.*, *Valvul.*, cap. iv., obs. xv.; &c.;] by Winslow, Part II., p. 126, n. 387; and the account of it collected from various sources, *Ibid.*, p. 199, 200, n. 409; where the following words occur: "Besides the pulmonary arteries and veins,—as it were, the mistresses,—there are also certain handmaids and domestics, termed the bronchial arteries, which (arising either from the great artery, at the beginning of its descent, or from one or more of the intercostals, or from the œsophageal, or from some other root connected with the intercostals, in some cases as a single vessel, in others by two trunks, one answering to each lung, in others again by almost as many trunks as there are lobules,) take the same course as the former vessels, skirting along the bronchia, all the way to the ultimate stadia and plexiform reticulations of the lungs. In fact, the bronchial arteries not only keep step with the pulmonary arteries, and accompany them to the very end of their walk, but even by frequent anastomoses join footsteps with them, and form a general alliance," &c. See also the notes. These vessels, together with the nerves, formed the lungs. (*Ibid.*, p. 202, 203, n. 409, *n.*) They teach the pulmonary artery to play the artery, although it carries venous blood. (*Ibid.*, p. 203, 204, n. 409, *q.*) And many other particulars. (*Ibid.*, p. 203-206, n. 409.) So that this is the artery that penetrates immediately to the innermost parts of the lungs; and its blood, with the exception only of the superfluous portion, is not collected in a receptacle, like that of the pulmonary artery. In fact, we always find that there is something that flows in immediately towards the innermost parts, while the rest flows in mediately only, or through a receptacle. The former is the case with the hepatic artery in the liver, and with other arteries in other parts.

(*s*) This is too evident from the anatomy of the lungs to stand in any need of further comment: see Malpighi, Part II., p. 128—132, n. 388, 389, and the other authors quoted in the same chapter. The blood, sent from the heart into the lungs, as its grand capsules or appendages, never stops until it arrives in the last meshes and reticulations, that is, in the field of leasts, or in the parietes of the interlobular cells, where it flows round and round in a perfectly free arena. (*Ibid.*, p. 194, 195, n. 408, *x*, *y*.) The blood sent by the heart into the lungs, is no longer under the government of the heart, but under the jurisdiction of the

same time collected in a receptacle, that the centres may constantly supply their necessities therefrom. The trunks and branches of the pulmonary artery are all so many receptacles of the blood carried in from the heart, for these vessels admit of immense dilatation (*t*); therefore the blood is carried in by them into the networks and cells, not according to the vibrations of the heart, but according to the states of the respiration and of use; or what amounts to the same thing, it is taken out as necessity demands. It is continually *purified and prepared on the way to the centres;* which circumstance is better exemplified in the lungs than in the liver; for the pulmonary artery runs through perpetual centres where the sanguineous networks are situated (*u*),

lungs, and in this case the lungs govern the circulation of their blood according to their own states, or according to necessities; in short, they govern the circumferences from the innermost parts. (*Ibid.*, p. 194—197, n. 408, *x*, *y*, *z*.)

(*t*) The veins are so many receptacles of the blood; in a word, they can admit and retain an additional and larger quantity of it. (*Econ. A. K.*, tr. i., n. 190—198.) This is particularly the case with the pulmonary vessels, according to the experience of Malpighi, who observes, that "when a ligature is put upon the [frog's] auricle and heart, and the motion and impulse prevented that might otherwise be communicated by the heart to the vessels, still the blood is sent by the veins towards the heart; . . . and this lasts for several hours." (Part II., p. 197, n. 408 (*z*) *ad fin.*) The same thing is proved by the structure of the pulmonary vessels. "When we open lengthwise any portion of the pulmonary artery and vein," say Winslow and Helvetius, ". . . we meet with a great number of transverse rugæ, which are obliterated when these vessels are elongated." (*Ibid.*, p. 128, n. 387.)

(*u*) There are as many centres for lustrating the blood, as there are networks and cells; and wherever these are situated, whether in the middle, or at the surface, still they are centres. (n. 538—541.) The power that the lungs possess of purifying and circulating the blood, resides in the centres. (Part II., p. 194, 195, n. 408, and the notes.) This is also plain from the descriptions of anatomists, as from the following by Winslow, which is the only one that I shall here bring forward: "All the bronchial cells [or vesicles]," says he, "are surrounded by a very fine reticular texture, consisting of the small extremities of arteries and veins which communicate every way with each other. . . . The ramifications of the . . . two kinds of vessels in the lungs are sur-

and everywhere puts forth little branches; so that there is not a point, all the way to the very innermost, in which purification is not carried on just as in the centres. *It is then received by the centres, turned about, and digested,* by continual processes of expansion and constriction, thus of agitation, kneading, and as it were of digestion (*x*), much in the same manner as in the cells of the spleen: it is *discriminated* into two species, one of which is instantly absorbed by the veins, or is immediately transmitted into them by the arteries through continuous branches, and is transferred by them to the left cavity of the heart, their ultimate end; thus *the finer portion is chosen out, and sent forth for use.* But the part not desired by the veins, because still undigested and crude, remains in the trabecular meshes or cells, and in like manner as the former, is compressed, worked about, and kneaded, and continually applied to the little venous mouths, in order that if anything available shall have been disengaged from the kneaded mass, it may be imbibed; while the more volatile part mounts all the way to the surface of the viscus, and is applied to the delicate mouths of the lymphatics; thus *the viler portion is separated, sent away, and corrected on the way as in the centres* (*y*). And this very humor, thus corrected, affords moreover this use, that it serves as a vehicle and menstruum for the rest of the blood, which, as we said before, is to be derived, and has been derived, into that cellular and spongy tissue (*z*): thus *it is expended upon a middle use.* What remains at last is mere baggage and dead stuff; this is wrung out through pores and openings into the bronchia and trachea, from which it is either ejected in the form of sputa, or carried

rounded everywhere by the cellular substance, . . . and the rete mirabile of Malpighi . . . is formed by the capillary extremities of these vessels." (*Ibid.*, p. 125, 126, n. 387.) See also Malpighi, *Ibid.*, p. 128—130, n. 388.

(*x*) On this subject see above, notes (*m*) and (*n*). Respecting the almost similar mode of purifying the blood in the spleen, see Part I., p. 344, 345, n. 243; p. 352, 353, n. 246.

(*y*) The reader will find this also pointed out above, notes (*l*) and (*n*).

(*z*) See note (*o*).

out by the air itself impregnated with effete vapors (*a*). Thus *the residue is successively thrown out.* For the sake of this use, the lungs are furnished with their cellular and reticular texture; and for the sake of the former use, with their bronchial and vesicular texture. These are *the reasons of their conformation.*

544. If we examine the STOMACH according to the same series of progression of causes, or if we trace the causes continuously, it will be found that one cause succeeds another in a similar manner and order to the above; wherefore, for the sake of confirmation, it will be well to run over this field also. Food or aliment, dry and moist, are the *objects* [of the function of the stomach,] *or the materials out of which* [*the effects are produced*], and which, as we all know full well, *come from without;* for they are taken by the mouth, and are rolled down through the pharynx and œsophagus into the stomach, and *so are carried away by distinct paths immediately towards the common centre,* (not as in other organs to manifold centres,) *and at the same time,* inasmuch as the stomach is a single centre and great cavity, *they are collected* in it as *in a receptacle;* and still more manifestly in ruminants, which besides the large stomach, penula or venter, have also the reticulus, the cellular chamber or omasus, and the

(*a*) See note (*p*). This latter office of the lungs in fine concurs with their former office as refectories of the blood; for the aliments that are brought by the air, as we said before, are eliminated into the cells through the foramina of the bronchia, and commixed with the serum thrown out from the blood by the arteries, in order that the two may be refined and lustrated together: wherefore the Malpighian networks are intermediate between the vesicles and the cells: thus after the commixtion, the two [the aërial aliments and the serum] undergo the same process. Hence it appears, that the lungs have three offices assigned them; *one* office, to excite the organs of the body, and their energies, by respiration: a *second,* to recruit the blood, and raise it to arterial splendor, by the elements or aliments that the air carries in with it, as the cutis [recruits the blood] by the insensible transpiration: a *third,* to lustrate all the blood of the body, especially in the matter of its chyle, which is supplied to the heart by the liver and other sources. What I am now attempting to shew, is, that these three offices are instituted according to the same general law.

abomasus, all of which are receptacles (*b*); *from which the* stomach or *centre supplies its necessities.* As this alimentitious material proceeds to its stomach, it is not only sipped in the first instance by the tongue, the throat, and the œsophagus, and examined with a view to its purer parts, which are immediately imbibed (*c*); but it is also comminuted by the teeth, kneaded by the tongue, and besprinkled with saliva (*d*); thus *it is examined and prepared on the way to the centre;* and when

(*b*) Respecting these promptuary stomachs, see Glisson and Schurig, Part I., p. 118, 119, n. 92, 93. It is manifest enough that the stomach is the common centre into which the food passes down; but I have also endeavored to shew, that it consists of innumerable parts, which are to be likened to so many little stomachs, and therefore as it were little centres, and which examine and treat the minute pieces of the food in the same manner as the common stomach itself, only more perfectly. (Part I., p. 130, 131, n. 101, *p.*) Likewise that a species of rumination exists in the stomach. (*Ibid.*, p. 137, 138, n. 105, *f.*) In which way it the more clearly performs the office of a receptacle; particularly since the food is kept in it for a considerable time, and the chyliferous juices are drawn forth successively, that is to say, are taken out according to necessity, or according to the state of the stomach. But we may dismiss this subject, since it is sufficiently plain that the stomach is the receptacle of the food.

(*c*) The tongue examines the food taken, and even commences the function of the stomach: see Part I., p. 44, 45, n. 42, where the following words occur: "The glands of the first class, named glandulæ fungosæ or capitatæ, scattered and grouped round the edges and over the surface of the tongue, are the organs which take the first taste of the nutrient essences of the food, imbibe them with their little mouths, and transmit them through continuous ducts . . . immediately into the blood . . . The glands of the second class, or glandulæ semilenticulares, represent the same as the . . . glandulæ fungosæ: . . . not excreting saliva, as commonly supposed, but drinking the first extracts and occult essences of the food, . . . and satisfying and renovating the needy blood, and breaking its fast. This is abundantly proved by a multitude of effects," &c.

(*d*) The tongue distributes the saliva; and the saliva is not drawn from glands proper to the tongue, but supplied by a number of others. (Part I., p. 39, 40, n. 38, *m;* p. 81, n. 70.) Likewise the œsophagus. (*Ibid.*, p. 98—100, n. 81.) From which it is plain, that an action

it is *received* therein, it is *worked* and *digested*, as we all know, by peristaltic motions; and it is equally certain that the purer essences, converted into chyle, and separated from the more feculent parts, are sent away into the veins, and into the lacteals or lymphatics (*e*); consequently, that they are *discriminated*, and then *the finer parts are chosen out*, and *sent forth for* the common *use* of the body; that is to say, for nutrition: moreover, that the undigested and more feculent, or *viler portions*, are *separated* and *sent away* through the pylorus into the intestines (*f*): and that they are worked and digested in the intestines in the same manner as in the stomach (*g*); or *are purified on the way, as in the centre;* the part that then seethes from them, is derived into the lacteals and veins, that it likewise may serve the common object (*h*), or *be expended upon*

similar to that in the centre or stomach, exists and is continued on the way to the centre.

(*e*) The stomach transmits the chyle into veins that go to the liver. *(Ibid.*, p. 137, 138, n. 105, *g.)* And into lymphatics, to go to the receptaculum chyli. *(Ibid.*, p. 136, 137, n. 105, *c*, *d*, *e.)*

(*f*) The stomach rejects only the cruder parts of the food into the intestines, or the impurities that are to undergo further castigation and digestion. *(Ibid.*, p. 138, n. 105.) Likewise one intestine into another. *(Ibid.*, p. 160—162, n. 126, *k*, *l*.) In the alimentary canal, from the mouth, through the œsophagus, stomach and intestines, to the rectum, all operations proceed successively according to the articulations. *(Ibid.)*

(*g*) The intestines act in the same manner as the stomach, working and digesting the food, and drawing the chyle out of it, and are as it were a continued stomach. *(Ibid.*, p. 157, n. 124; p. 158, 159, n. 125, *f*, *g*, *h;* p. 161, 162, n. 126, *k*, *l.)*

(*h*) It is well known that the intestines throw out the chyle into the lacteals of the mesentery. (See Part I., p. 171, n. 131 (*g*); p. 196, n. 149; p. 198, n. 150.) Respecting the function in this kind of each intestine specifically, see *ibid.*, p. 173—185, n. 134—140. It may also be seen that the chyle of the intestines is of a middle use, and that the chyle of the stomach conveyed by the lacteals to the receptaculum chyli and the liver, is primary; not only because the former is grosser, and less suitable to the blood, than the chyle that is copulated with the blood in the glands of the liver, but also because the urinous serum thrown out in such abundance by the bladder, comes from the

a middle use. The other parts are rejected as fæces into the large intestines, where again a similar process goes on; but *those parts that are utterly worthless* are discharged by the rectum (*i*), or in the words of the proposition, *the residue is thrown out.* The stomach with its appendages and auxiliary cavities is fashioned to produce the series of all these causes and effects; wherefore *the whole ratio of its composition* is contained in them.

545. But let us close this first division by an examination of the HEART in the same series of progression of causes; which, namely, the heart, like the stomach, is a single cavity, or common centre, that has ministering viscera connected to it, that institute this series of operations conjointly with it, as their common centre: in the same manner as the œsophagus above, and the intestines below, are adjoined to the stomach, as appendages, so the lungs above, and the liver below, are adjoined to the heart; the pancreas, the spleen, and the omentum being adjoined to the liver again, as ministers. *The object* of the heart, *or the material out of which* the body is nourished, or *by means of which* the circulation is carried on, is the blood, which the heart purifies in its circle, and prepares for future uses. We all know that this material, I mean the mass of the blood, *comes from without,* namely, from all the viscera of the thorax and abdomen, and from their innermost, that is, ultimate and extreme parts, wherever any little venous mouth opens; or else from the whole cuticular circumference, or from the outermost, that is again, from the ultimate and extreme parts. This blood *is immediately carried away by distinct paths,* or by the veins, *towards this* the common cardiac *centre;* but immediately by those that run over the surfaces of the vena cava and right auricle of the heart, and pass into its auricular sinus by peculiar entrances (*k*). *And at the same time it is collected in a receptacle,*

intestinular chyle principally. It serves the blood as a vehicle. (*Econ. A. K.,* tr. i., n. 49.)

(*i*) See Part I., p. 183—185, n. 139, 140.

(*k*) The reader will find these vessels treated of in my *Econ. A. K.* tr. i., n. 428—430. They are there termed auricular vessels, and seem to correspond to the bronchial arteries in the lungs, and to the

or in the vena cava, which forms a receptacle to the right auricle of the heart; besides which, all the other veins are so many receptacles and storehouses (*l*); *from which* the heart, or this *centre supplies its necessities*, in exact accordance to the law of use and want (*m*). This blood is *purified and prepared on the way to the centre* or heart, by the liver, which is as it were the gate for the veins of the abdomen to the inferior vena cava (*n*). It is then *received* by the heart, is *worked about* by its motions, or systole and diastole, and is next thrown through the pulmonary artery into the lungs, as the great capsules and appendages of the heart (*o*); where it is *digested, discriminated into*

hepatic arteries in the liver. They appear to be analogous to those arteries in function and use, and like them to go in by a short cut, and immediately. Consequently these vessels should be distinguished from the common vessels, or the true veins; as also should the coronary vessels, of which we shall speak presently.

(*l*) The veins are receptacles. (*Œcon. A. K.*, tr. i., n. 190—198, and *Animal Kingdom*, n. 543, *t*.) Also the right auricle of the heart. (*Œcon. A. K.*, tr. i., n. 514, 519, 538—544, 569.) The auricle may vibrate several times while the ventricle vibrates once. (*Ibid.*, n. 519.) The ratio of the vena cava to the auricle is as that of the auricle to the ventricle. (*Ibid.*, n. 520—523, 526; also n. 527, 529.)

(*m*) The cause of the heart's action is the pressure of the blood of the two venæ cavæ; and the blood does not flow in according to the quantity in the venæ cavæ, but what is necessary is taken out from them as receptacles. (Part I., p. 337, 338, n. 239; p. 350, 351, n. 245 (*d*); p. 359, n. 248; Part II., p. 245—247, n. 425 (*x*); *Œcon. A. K.*, tr. i., n. 514—544.)

(*n*) As shewn above in speaking of the liver (n. 542); for all the vessels that flow into the liver from the stomach, intestines, mesentery, pancreas, spleen, omentum, diaphragm, and peritonæum, are veins and not arteries. It was pointed out before, that the office of the liver consists in lustrating the blood and chyle received, and preparing them for the heart.

(*o*) The lungs are appendages and capsules of the heart, and purify the blood sent in by the heart. (n. 543; and Part II., p. 194—197, n. 408 (*x*, *y*, *z*); p. 235, n. 423; p. 335—338, n. 457.) This is clear from the production of the pericardium, which envelops all the vessels of the lungs, as the capsule of Glisson envelops the vessels of the liver, &c.

parts, and *the finer portion of it chosen out, and sent forth for use* into the left cavity of the heart; *but the viler portion is separated, sent away, corrected on the way as in the centres, and expended upon some middle use; and the residue, which is worthless, is thrown out* (*p*). This takes place in the lungs. But besides this, the heart itself is an organ for preparing liquids for the composition of the blood (*q*); and at the same time is the beginning of the circulation of the blood: for the blood is not only *worked about* and *digested* in the heart, but also *discriminated into parts;* in short, the purer essence is driven out into the coronary vessels (*r*); and the grosser is sent away into the lungs. The part that was transmitted into the coronary vessels, flows out into the beginning of the aorta, and so into the aorta (*s*); consequently, *the finer portion is chosen out* by the heart, and *sent forth for use;* but *the viler portion is separated, and sent away* into the lungs, and poured back by them into the left chamber of the heart. After this blood is thrown out by this chamber of the heart into the aorta, and as it runs down along the arteries, throughout, *on the way*, it is compressed, teazed, and *corrected in the same manner as in the centre*, or heart, for there is a likeness of the heart's action in every point

(*p*) As proved above, n. 542, in the description given of this process in the liver; for these operations are carried on in the same manner in the lungs.

(*q*) The heart is a chemical organ, preparing liquids for the composition of the blood. (*Econ. A. K.*, tr. i., n. 453—457.)

(*r*) See this proved by many considerations in *Econ. A. K.*, tr. i., n. 454, 455, &c.

(*s*) The coronary vessels of the heart do not arise from the aorta. (*Econ. A. K.*, tr. i., n. 399—402.) But [the coronary blood runs] from the heart through the lacunæ. (*Ibid.*, n. 403, 405.) And through the moving fibres into the coronary vessels; and is the finer essence of the blood. (*Ibid.*, n. 404—407, n. 453—457.) From the coronary vessels into the aorta. (*Ibid.*, n. 415, 416.) These vessels depend upon the action of the heart. (*Ibid.*, n. 418, 419.) They are the veins of the heart. (*Ibid.*, n. 421, 422, 459.) Hence they are on the same principle as the bronchial vein in the lungs, and the hepatic vein in the liver.

of an artery (*t*): and wherever an artery goes, its blood is sent away to the adjacent and neighboring viscera, in order to perform useful service; *thus it is expended upon a middle use* (*u*). The part of the blood that has done its work, or is antiquated and useless, is conveyed to the kidneys, and by them to the ureters and bladder, from which it is thrown out through the urethra in the form of urine; or else to the ultimate pores of the skin, to be eliminated in the form of sweat; in this manner *the residue, which is worthless, is thrown out.* These are the *reasons of the composition* of the heart; of its position under the lungs; of its connexion with the lungs by the vessels and the pericardium; with the liver and the other viscera, by the veins and the diaphragm; and with all parts by continuous vessels: for since the heart is a common centre, the ratio of its composition must be sought not only from its own form, but also, in the complex, from the common form of the whole body; consequently from its connexion with all those viscera that attend upon it, and to which it is itself of service.

546. In the CEREBRUM again causes proceed through the same series as in the fabrics and organs of the body already spoken of, and which formed the first division of our subject. But the offices of the cerebrum consist in generating, bringing forth, putting in circulation, and purifying, the spirit of the blood, and thus maintaining the labors and lives of all the viscera of the body: also in receiving sensations from the organs of the body, and conducting them to the innermost sensorium; and carrying into effect the actions that are intended there (*x*). With respect to its first office, or the generation of the spirits, which is carried on in its cortical glands (*y*), it is evident that

(*t*) In every point of an artery there is a likeness of the action of the heart. (*Econ. A. K.*, tr., i., n. 507, 570.)

(*u*) Whatever the blood affords, is but a middle use; an ulterior end, for which the blood exists, is always kept in view. (Part I., p. 377, 378, n. 260 (*n*, *o*); Part II., p. 361—366, n. 464—466.)

(*x*) It will be shewn in the next Part, in treating of the Cerebrum, that these are its primary offices. The cerebrum acts as a sensorium (n. 468, 528).

(*y*) See above, n. 507, and *Econ. A. K.*, tr., ii., n. 165—168.

the object or material out of which or by means of which [the spirits are generated], *comes from without;* I mean, that most fine embodiment or bond that is to serve for preparing that spirit; it comes, namely, from the subtlest pores of the cuticle, through what I have above denominated the corporeal fibres (*z*); and also through the arteries, which run in multitudes to the cortical glands of the cerebrum, and connect themselves by their extremities thereto (*a*); consequently, from without; for whatever is in the body is extraneous to the cerebrum. These principles or centres, which are the cortical spherules, are the innermost of all, because the highest; wherefore they regard the arteries that go to them, and the proper fibres of the body, as extraneous to themselves; consequently this material is *carried away immediately by distinct paths towards the centres.* The blood abounding in spirit is also collected in divers places within the medullary portion of the cerebrum, and close under the cortical layers, in great numbers of diverticula and receptacles; in order that it may be ready to flow in according to every

(*z*) This most subtle matter is insinuated and drawn up towards the cortex cerebri through the cuticular pores of the first kind, and through the very minute vessels continued from them, that is, through the corporeal fibres, which construct the innermost coats of the arteries. (See above, n. 504, 507, 509.)

(*a*) The arterial twigs apply themselves to the cortical substances, and pour into them the spirit of their blood. (*Econ. A. K.*, tr. ii., n. 117—127.) This will be further proved in the Analysis of the Cerebrum. In these respects there appears to be a parallel between the cerebrum and the organs and viscera of the body; for that most fine vessel termed a corporeal fibre, and conveyed to the cortical substances of the cerebrum, is analogous to the bronchial artery, which is carried immediately to the cells of the lungs; and to the hepatic artery, which passes immediately to the glands of the liver. But the arterial twigs that are connected to the glands of the cerebrum, and put into them the spirit of their blood, are like the pulmonary arteries in the lungs, and the portal vessels in the liver, which form receptacles, or are brought from receptacles: so that when a comparison is instituted, the one is easily recognized in the other. The cerebrum demands back the spirit from the blood, and transmits it into the fibres. (Part I., p. 213, n. 162 (*a*); p. 237, n. 181; p. 318, n. 245, *y*.)

intimation, necessity, state, and operation of the mind, (as will be seen from the anatomy of the cerebrum); thus *it is at the same time collected in a receptacle,* or in receptacles, *that the centres,* or cortical glands, *may constantly supply their necessities therefrom.* The blood itself, and its spirit, are purified throughout in the ascent towards these supreme organs and sensoria; the recrementitious portion being so completely carried off by innumerable glands on the way, for instance, by the œsophageal, tracheal, pharyngeal, palatine, maxillary, parotid, and other salivary glands, that none but the blood of the most refined kind, and the purer blood, enters the cranium; as shewn by the very nature of that blood when explored even chemically by anatomists (*b*); wherefore the blood is *examined and prepared on the way to the centres.* Afterwards its spirit or lymph, which is also called the colorless blood, is carried into the glands as its little laboratories, and shaken about, mixed up, and prepared for its uses in them, as is the red blood in the cells of the lungs, or in the glands of the liver; that is to say, by the alternate expansions and constrictions, or animations, of the cerebrum, or of its organic, that is, cortical principles (*c*); and thus, when it is *received by the centres, it is worked about and digested* therein. At the same time again, as in other parts, it is divided into two species; into a finer species that is transmitted through the fibres in all directions into the regions and members of the body; namely, into the muscles and the organs of the senses; thus into the one and the other for the common service of all parts; consequently, according to the proposed law of order, it is *discriminated into parts, and then the finer portion is chosen out, and sent forth for use.* But the species of

(*b*) The blood that is about to ascend to the cerebrum, is purified by the extraction of the saliva by the salivary glands. (See Part I., p. 85, n. 72, *n*; and the following pages, where I propose to treat of the external Senses of the Head.) The cerebrum attracts the finer blood. (*Ibid.*, p. 337, 338, n. 239; and *Econ. A. K.*, tr. ii., n. 125—127.)

(*c*) The animatory motion of the cerebrum takes its rise in these its glands, and the whole cerebrum is carried into motion by them, as the lungs by their vesicles; and these glands are like little hearts. (*Ibid.*, tr. ii., n. 132—142.)

a lower character is derived towards the chemical organs of the cerebrum; namely, to the lateral and third ventricles, the infundibulum, and the pituitary gland; and wherever it goes, it is corrected and purified in the same manner as in the principles; according to what will be proved in the Analysis of the Cerebrum; thus *the viler portion is separated, sent away, and purified on the way, as in the centres.* But what is brought forth by these chemical members of the cerebrum, is poured into the extreme receptacles of the lateral sinuses, namely, the jugular veins, to serve as a medium for copulating the spirit with the chyle (*d*); and so be of manifold use; thus *it is expended upon a middle use.* But the rest, or the perfectly dead portion, exhales in immense quantity through the cuticular pores, as the Sanctorian perspiration teaches (*e*); wherefore *the residue, that is worthless, is thrown out.* This *is the reason of the conformation of the cerebrum* to the sensorial and motorial organs of its body, and especially to the papillary organ of the cutis, which affords the cerebrum the most marked assistance in this its function.

547. But this same progressive series of causes is conspicuous not only in this office of the cerebrum, I mean, in its chemical office of preparing an essence more universal than the blood, namely, what is termed the animal spirit; but it is also evident in its second, or SENSORIAL AND MOTORIAL OFFICE. For as the sensorial and motorial organs act, so the sensations and motions that result from them are exhibited: the one conforms to the other, as predicate to subject, accident to its substance, or mode to its forces. But to come to the point. Every *object,* or all the *material out of which and by means of which* [*the effect*

(*d*) This lymph serves as a link or bond of union, to enable the spirit to be married to the chyle, and the generation of the blood to go on. (Part I., p. 214, 215, n. 162, *e, f, g.*) For this end, the lymph of the cerebrum, full of spirit, meets with the lymph and chyle of the body carried up by the thoracic duct, in the subclavian vein. (*Ibid.*, p. 252, n. 190.) But of these subjects I shall treat professedly in the Analysis of the Cerebrum.

(*e*) The viler parts of the purer blood, or lymph, which pertains to the animal spirit, are thrown out by the Sanctorian perspiration, and not the viler parts of the red blood (n. 510).

is produced], *comes from without;* in other words, whatever is to produce any sense in the sensorial organs, flows in from without; for instance, images flow from without into the eye, whence sight; sounds and tones into the ear, whence hearing; subtle halitus into the nares, whence smelling; alimentitious particles to the tongue, whence taste; and more considerable impulsions to the cuticle, whence touch. *These are carried away by distinct paths towards the centres;* namely, by the sensorial fibres, as of the olfactory, optic, and auditory nerves, all the way to the cortical substances, the ultimate boundaries of the fibres (*f*), or the veriest centres. Certain species of sensations are raised and penetrate immediately to their innermost recesses (*g*); but certain others betake themselves into the memory, as into a kind of receptacle; agreeably to the proposition, *that they are at the same time collected in a receptacle;* the images are not only laid up in this receptacle of the memory, but they are also called forth from it for every use; *so that the centres,* or the cortical substances with their principles, which jointly constitute the common sensorium, and include the innermost sensorium, *constantly supply their necessities therefrom.* These objects are purified on the way; as is plainly shewn not only in the objects of hearing, which as they ascend,

(*f*) The cortical substances are the ultimate boundaries of the fibres, and consequently the ends whither the sensorial modifications mount; and taken collectively, therefore, constitute our common, and include our innermost sensorium. (n. 528, *f*, 529, *h*, *i*.)

(*g*) We shall have occasion to remark in the course of our analytic investigation of the external senses, that certain species of sensations go immediately towards the innermost sphere, and are not laid up at all in the memory as a receptacle; for they do not form ideas of the nature of visual ideas. They are analogous to those arteries mentioned above, as existing in the liver, the lungs, and the cerebrum, and which run in immediately towards the glands, without insinuating themselves into a receptacle. At first sight, indeed, the comparison may appear far-fetched, and perhaps abstruse; yet the same order prevails everywhere between subjects as between predicates, as we said before, and hence the third term in the comparison cannot fail to offer itself also by a species of representation; especially when we abstract our ideas from subjects, and attach them to the operations of subjects.

and before they enter very far, put on a form like that of the images of sight; but also in the objects of sight, which when they are called forth from the storehouse of the memory, and raised to a higher point, put off the material form, and put on a kind of immaterial form, that so images may be transmuted into intellectual ideas; thus according to the law, the objects *are examined and prepared on the way to the centres. They are* then *received by the centres*, and taken into the sphere of the thoughts, where they are *turned about*, that is, discussed in various ways, or *digested*. Afterwards, when so discussed, they are *discriminated* into two species, of which one, *as being the finer, is chosen out, and put forth for use*; in other words, what is considered and chosen as a good, is determined by the will into act, that it may be of use: but *the viler* species *is separated and sent away*; that, namely, which is to be likened to evil that yet has something of good in it, and which therefore is not rejected, but has to be discussed and expurgated before it is remitted into the society of good: thus *it is purified on the way as in the centres*; in fact, in order that it may serve the final cause as a *medium, it is expended upon some use*. When it is purified, what remains is accounted so vile that it is utterly rejected; for were it admitted to fellowship with good, it would absolutely contaminate it, and destroy the progressive series of ends and means: this is called evil; thus *the residue, which is worthless, is thrown out*. For everything that is turned over and considered in the sphere of the intellect, has respect to nothing but truth and falsity, and these again to good and evil. What appears the best is always chosen, and what appears the worst is rejected; but what is intermediate, and about which we are still in doubt, is further discussed, and for the most part is assumed as a means of eliciting first truth and then good; the truth and good brought out by it are associated with the former truth and good, but the remainder is condemned and thrown out, as dross from which the gold has been extracted. *Such is the influx of sensations into our intellect; such is the treatment of those that flow in; and such the influx of the will into actions: or if influx is predicated of sensations, efflux must be predicated respectively of actions.* But how this universal series of sensations is circumstanced, in all its amazing extent,—of

this we must be instructed by the sensoria; in the first instance by the external sensoria, or those of the body, and afterwards by the internal sensoria, or those of the cerebrum, to which let us now proceed forthwith. I have felt it my duty to bring together in one place these considerations, derived from the investigations into the viscera of the body that we have already instituted and completed, on the threshold to the exploration of the organs of the senses; lest without some common mirror, we should wander in uncertainty through labyrinths of varieties, which are as infinite as the diversities of uses and ends.

THE SENSE AND SENSORIUM OF TOUCH SPECIFICALLY.

548. *In the papillary organ of the cutis, as in a mirror, we may contemplate the sense of touch, and see the nature of that sense; and* vice versâ: *the one being exactly represented in the other;* for the fibres are put together and the form conceived with reference to every kind of variety and idea of use; as the papillary form with reference to touch (n. 531). In order to the existence of a sensorium that can apprehend the several varieties of an object with their differences and distinctions, the fibres must be disposed into an organic form (n. 531). By a similar contemplation of the one thing in the other, [that is to say, of the sense in the organ,] we are instructed respecting the rest of the senses. Thus, by the papillary surface of the tongue we are instructed respecting taste; by the papillary surface of the nares, respecting smell; by the sonorous tympana and laminæ of the ears, respecting hearing; and by the construction of the two chambers of the eye, respecting sight: for wherever there is a sense, there is a sensorium also; wherever there is a force and modification, there is a substance also; in short, wherever there are accidents, there are subjects also: the one thing flows from the other, as something from something. And thus from the organic fabrics themselves, when anatomically unfolded into their parts, and examined scientifically, we may conclude, not conjecturally but certainly, respecting the offices that are performed (*h*).

(*h*) I have very frequently endeavored to shew, that a diligent anatomical investigation, penetrating down to parts, and connexions of parts, has the especial result, of enabling us to search out thence, and survey as in a mirror, the uses of the viscera. (See Part I., p. 33,

549. *We see from this papillary organ, that the papillæ that rise through the foramina of the corpus reticulare, represent the unities of our touch; and that by the mutual apposition of these unities, and their orderly association, an organic form is produced, which is the organ, or as it is commonly called, the sensorium of touch. The scales of the epidermis regulate and temper the sense to suit every use that can possibly be intended in these extremes.* Every viscus and organ has its proper unities (n. 532); which are either glands, or cells, or fibres of some kind, or papillæ (n. 538). These unities are the essential determinations that construct the form of the whole, or the common form (n. 539); for compounds are aggregates of unities (n. 541). In the skin, the corpus reticulare collects the papillæ that would otherwise fall asunder and be scattered, bridges them over, gives them distinctness, reduces them to form: thus causes everything to refer itself to a general (n. 499). The scale of the epidermis puts together the individual modes of sensation proper to the papillæ, into a kind of common mode that is termed the sense of touch; and regulates, sharpens, and blunts this sense, so as exactly to produce the varieties that nature requires of it in the different parts of the body (n. 494). To which we may add, that the scale blunts the sharpness of the sense, and so mitigates its poignancy as to convert it into titillation; thereby changing pain into pleasure: for itself devoid of feeling, it enables the organ to feel according to the softness of the surface that it applies to the organ: but where it dips down into the furrows, and is more thin, there the sense is sharp again.

550. *From these considerations it appears, that touch is the most obtuse and indistinct of all the senses; and more obtuse and indistinct in proportion as a larger number of papillæ is pressed, or affected, at the same time.* Organic forms are perfect in proportion to the simplicity of the forms that they commence from, and which are their unities (n. 532). Thus we are to judge

34, n. 32 (*d*); p. 341, n. 241; p. 377, 378, n. 260 (*n*, *o*); p. 379—381, n. 260 (*s*); p. 430, 431, n. 286 (*g*): Part II., p. 141, n. 393; p. 361—366, n. 464—466, and the notes.) For all causes flow according to the nexus of substances: predicates and accidents must flow from substances as their subjects.

from unities of the perfection and acumen of sensations; in other words, from differences, which are equivalent to unities. The unities of the sensorium of touch, which are papillæ, again associate, and place themselves under scales, which compact these papillæ, or a number of them, into a new and therefore compound unity (n. 533, 549). The relation of discriminations perishes and is in a manner confounded in the compound; as for instance, in everything simultaneous, and in every continuous quantity; succession and separation [*discretum*] are necessary conditions in order that individual things may appear distinctly. The melody of a song is distinct when the notes succeed each other in becoming order; and the more so when many accordant notes follow in series: but if these were compounded into one, there would be no pleasing result, except it were caught by anticipation from the idea of successivity. In conversation likewise, we have a distinct perception of the subject, when one sentence falls cleverly into another, as [in the other case] we have a distinct sensation of the divisions of sound. The eye sees more acutely when it is fixed on any point of an object, than when it is diffused over the whole; and indeed the microscope presents the surface of an object more distinctly if a small portion only of such surface be placed in its field. The same rule obtains in other cases; for all distinctness perishes in an indiscriminate heap and multitude of things (*i*). Precisely so it is with the little sensoria of touch compacted together under the scales of the epidermis: a limited number of papillæ, that is to say, a few, not only distinguish a fine thread of wool, but even whether it be rough or smooth; while many together, (for instance, if we feel the object with the palm of the hand,) scarcely perceive that it is wool at all. A point of the skin stricken by the heat of the sun, may be so

(*i*) It is to be observed, that in the determination of organic forms, there is always a progression from a lesser unity to a larger. Let us instance muscular fibre: the first unity here is the least moving fibre, which produces a larger fibre, properly called a moving fibre, as a compound unity: these [larger] fibres again, by composition, form an entire muscle, which is the largest unity; for that there are relatively larger and lesser unities, see above, n. 532 (*r*).

burnt as to lose all feeling and produce dangerous symptoms; a point attacked by cold or draught may stand on end, give pain, and grow numb; and yet when the same wind or heat catches a whole limb, it may be scarcely felt at all: for what is acute to one papilla, is diffused when many are associated together, and refined away; hence is rendered obtuse and indistinct.

551. *But this sense may be rendered more acute and distinct in various ways; nay, it is actually more distinct wherever use demands it.* We have instances of its increased acuteness, in luxurious, effeminate, fair persons, in those who follow no occupation, or are naturally delicate in body, in infants, in the blind, in those whose attention is directed to different parts of their skin at different times, and who are anxious on account of any spot or pustule that seems to forebode a mortal disease. On the other hand, we have instances of its increased obtuseness, in those whose skins are hardened, as husbandmen, cooks, porters, workmen, culprits often striped and wounded by the lash, in persons whose nerves are relaxed in consequence of the subsidence of swellings, in decayed old subjects, and many others. Which shews that this sense admits of a wider or narrower sphere of perfection; being perfected with the form or organ; for the one is exactly represented in the other (n. 548): it is perfect, that is to say, in proportion as the papillæ are placed distinctly with respect to each other (n. 535): in proportion as they are distinguished from their companions by variety, and at the same time are conjoined with them in fitting harmony (n. 536): also in proportion to the promptitude and ease with which they can change their states, and relapse into their pristine natural state (n. 537). Or specifically speaking, in proportion to the thinness of the epidermis with which the papillæ are covered; in proportion as they are separated distinctly by the corpus reticulare, and at the same time bound down or devoted heartily to the common service; in proportion as the series of them are well discriminated by furrows; and are seated upon a yielding basis. Nay, the papillæ themselves are perfect in proportion to the fineness of the little tunic that clothes them; and in proportion to the distinctness with which the fibrillæ that construct and weave them, act among themselves (n. 534, 535). For the form of the general, or the common form, is perfected, when the form of the

part or unity is perfected; therefrom as its root the perfection of the whole arises. We have clear evidence of the fact, that the sense of touch is actually more perfect where reason and use demand, from what we observe in the fingers, which are instruments for the exploration of objects, where the series of papillæ are seen to be arranged in spiral curves, and divided from each other by the intervention of furrows (*k*). And in the lips, which anticipate by touch the general character of the food about to be received by the mouth; the papillæ being, therefore, heaped together, and covered by a finer epidermis, in those parts (*l*). Also in the eyes, that is, in the conjunctiva, which serves as a guard to the pupil. This sense is also more acute in the parts covered by the prepuce, and which are designed to be excited by touch: for the form is conceived with reference to the whole idea of use (n. 531).

552. *In touch, as in all the other senses, there is first an* impression, *involving in it an* action, *either from some inert, or from some active force, that comes from without. Next, answering to the impression, a* mutation *in the excited part of the sensorial organ; and hence a* reaction *corresponding to the action. Then a* perception *of the mutation in the general sensorium, giving rise to a* sensation. *Forthwith, according to the perception, there arises an* affection: *according to the affection, a* disposition *to*

(*k*) The pyramidal papillæ, according to Heister, "are most conspicuous (. . . after the removal of the cuticle) in the lips, the palms of the hands, especially about the tips of the fingers, and in the soles of the feet" (n. 472). And according to Winslow: "The papillæ of the palm of the hand, of the sole of the foot, and of the fingers and toes, are higher than those of other parts, but smaller, closely united together, and placed as it were erect one against another, in particular rows, which represent on the skin all kinds of lines, straight, curved, waving, spiral, &c." (n. 473).

(*l*) "The red part of the lips," says Winslow, "is also made up of papillæ, resembling very fine hairs or villi closely united together. There is another peculiar kind under the nails. . . . Those [papillæ] which are found in the hairy scalp, scrotum, &c., are again of other kinds" (n. 473). Thus it is plain, that touch corresponds exactly to the form produced by the papillæ, as pointed out above, n. 548.

the preservation of the part or the whole; or a change of state *in agreement with the affection: then an* effect *embodying the* use *that the sensation produces.* Causes enter successively into every effect, for an effect is the ultimate of an orderly progression of causes; and therefore is to be considered in the same light as the equation of an analytic, that is, algebraic calculus, in which are put several mutually connected lesser equations, hence several ratios and analogies, in order that they may be together therein. Thus it is our business to resolve an effect, in the same manner as we should resolve such an equation, into its parts, or causes, so that we may know what it contains, and whence it exists. Such being the order of efficients, it follows, that all the things that precede, coexist in the last efficient, or in the effect; in a word, that the effect is the complex and sum of what has gone before it. With regard to touch specifically, we find by contemplating it in its causes, that the object coming from without (n. 542—547), first imprints an image of itself upon the sensorial organ; whence an *impression,* with an *action* accompanying it; and at the same time, since the organ suffers itself to be moulded to the pattern of the thing impressed, there exists a *mutation* of the parts or links constituting the organic form; and this form, when changed, inasmuch as it endeavors to relapse into its pristine state (n. 537), reacts upon the object in proportion as it is acted upon; hence *reaction.* This series of causes, or this prior effect, (to wit, the impression and mutation, together with the corresponding action and reaction,) is forthwith carried by the fibres to the cerebrum (n. 547), which alone feels, the organ of the body acting the part of an instrument merely (n. 528); hence a *perception,* which united with the above mutation, or the first effect, is properly termed a *sensation.* If anything endangers or dissevers the associated parts of an organ, some uneasiness or pain instantly makes the circumstance manifest (n. 529): but if anything soothes or reinstates them, it gives rise to delight and pleasure, which is felt by the whole mind; thus we are affected according to the mode of the mutation and sensation; and hence arises an *affection.* The papillary organ of the cutis is extremely susceptible of changes from every slight affection (n. 517); either suffering expansion or constriction, elongation or retraction, soften-

ing or hardening (n. 490); in a word, *change of state*; which if it proceeds from an affection of the animal mind,—if thus it flows as it were spontaneously,—then the same change or mutation has in it a *disposition* to the preservation of the part or the whole; for instance, the expansion, elongation, and softening, have in them a disposition for enjoying pleasure; and on the other hand, the constriction, retraction, and hardening, for avoiding pain and misfortune. But if it proceeds from the rational mind, and not from the animal mind, or what amounts to the same thing, from the will and not from nature, the muscles are immediately called into play, either to receive delights, or to avert dangers; in this manner an *effect* is presented that embodies the *use* that the sensation produces. There is a similar successive order of causes, from the first to the last, in the other senses. Let us confine our attention to the sense of *sight*: first, the image of an object is offered to it, and as this image flows in through the pupil and the crystalline lens all the way to the retina, therefore an *impression* is made by an active force, or an *action* takes place (n. 523); consequently an answerable *mutation* and *reaction* in that delicate villous network. The image itself is carried by the optic nerves to the general sensorium, where it is perceived; and hence we have a *perception*. Beautiful sights and harmonious varieties fill the animal mind with pleasure, and the rational mind with joy; ugly sights and inharmonious varieties disturb and horrify; the view of dangers terrifies and stuns us: thus an *affection* arises according to the perception or sensation. According to the state of the affection, the animal and rational mind are either dilated, or straitened, or disturbed: likewise the blood with its vessels, and the spirit with its fibres, which are compliant and obedient to their animal and rational minds, and are either unfolded or contracted, or relaxed or indurated, or tremble with joy or fear, or in common with their principles undergo other changes. Thus a *change of state* results from the affection; or a *disposition* of the muscles at the discretion of the mind; that is to say, a voluntary action for the enjoyment of delights, or for escape from dangers; which is the *effect* that comprehends in it simultaneously this whole series. A similar series, running from the first cause of sensation to the effect, is presented

actually in every viscus of the body (*m*): for nothing undergoes any change different from the natural state, without a premonitory sense. Thus in the stomach, the objects themselves, or the parts of the food, solid and fluid, excite its papillary membrane, imprint their image upon that membrane, and act upon it; whence there exists an *impression* and *action;* but in the papillæ, a *mutation* and *reaction.* These being carried up by the fibres to their principles, the cerebellum is affected correspondently (n. 526, 527); whence an *affection,* which brings on a sudden *change of state.* For the vermicular motion of the stomach is either increased, or slackened, or inverted; or else the whole periphery of the cavity is expanded, and acts softly, or is contracted and hardens; whence a *disposition,* for the food to be treated in this way or that; to be hardly dealt with, and in a manner triturated; or digested more softly or slowly; or rolled down into the intestines gradually; or precipitated thither off-hand. This is the *effect* and *use* that the sense of touch produces.

553. *The papillæ are expanded, extended, and soften, when they come in contact with a pleasant object; but are constricted, retracted, and harden, when they come in contact with an unpleasant object.* External sensations, or the sensations of the surface of the body, are but mutations corresponding to the external surface and figure of the thing impressed; for that which feels, or which perceives the mutation, does not reside in the outside shell, I mean, in the skin, but in the centres or the beginnings of the fibres (n. 528). Yet as the instrumental or organic makes one effect with its principal, hence sensation may conveniently be predicated of both; yea, and feeling itself, which simulates the existence of sensation in the ultimate sphere, leads us to believe that this appearance is a reality. That these mutations produced by impressions, consist in expansions, extensions, and softenings of parts, is clear from the relaxation and erection [exsertatione] of the papillary organ, or

(*m*) This is nowhere so conspicuous as in the kidneys, which excrete such various kinds of urine, answering, in fact, to every change of the blood and serum; as shewn in the Chapter on the Kidneys, Part I., p. 454, 455, n. 295.

of the whole cuticular surface, in the breathing warmth of spring, in warm apartments, or when we are warm in bed under the clothes and the coverlet; and still more when we are surrounded by the summer heat, or are in the warm bath, or the vapor bath; when the above effect occurs to such an extent, that the pores and ducts of the skin open, the fibres being relaxed and elongated, and the whole surface is covered with drops of sweat. It is also plain from the fearlessness of nature and the fulness of sensation that are created, by the application of soothing, innocuous, yielding, soft, feathery substances, and by those of which the friction is agreeable. On the other hand, that these mutations consist in constrictions, retractions, and hardenings of parts, is plain from the skin itself, when a bitter wind strikes and catches it, or when it comes in contact with anything cold, rough, prickly or hard: and even from the fear of injury when similar things assail it; and from the play and free motion of the same organ when any object with a varied surface wanders over it, and titillates it. The mutations of state are equal in number to all the possible affections of the body, the animal mind and the rational mind; consequently to all the possible unfoldings, elasticities, activities, and lives, of the vessels, fibres and papillæ; and on the other hand, to all their possible foldings, constrictions, and privations of life, with their infinite species, differences, and degrees. Given the unity of the organ, and we have then the possibility of mutations, for this possibility increases in proportion as the unity increases in purity and perfection (n. 532, 550).

554. *Whatever soothes the parts and cements their union, is pleasant; but whatever twinges and destroys, is unpleasant.* The love of self-preservation, renewal and life, is as paramount in the body, as in the mind and the soul; that is to say, in the last sphere as in the first. The very union [between these], and the fruition of uses by that union, excite this love naturally, and diffuse it through the whole system. Sense is [the medium] by which the life of the body enters, and the love of life itself. From the ground of this love it is, that delights proceed from those things that renovate, and pains from those that destroy. Both the former and the latter have their own proper mutations; the former, tion unfoldings, the elasticities,

and the very activities of life; the latter, the constrictions, hardenings, benumbings, as it were the images of death (n. 553). But inasmuch as three distinct spheres prevail in the body (n. 468), between whose chieftains there is perpetual battle and collision (n. 518), hence it happens, that each of these,—albeit they unite their loves for the sake of common uses,—consults its own ends, and favors itself. Thus one not unfrequently opposes and disperses the pleasures belonging to the life of the other; wherefore our intellectual mind, aware of the fallacies of the bodily senses, frequently rejects their delights and favors; nay, sometimes chooses and devotedly loves what is unpleasant to the senses. From this source, in a very great degree, result the ideas of pleasant and unpleasant rising freshly from the senses.

555 *One thing joined to another with becoming variety, remarkably exalts the life of sensations.* Equalities are the very disgust of sensations; but varieties, and harmonious varieties especially, are their delight. Hence the sensoria are fashioned for receiving infinite varieties; so it is with the papillary substance of the cutis, and so with the tongue, the nares, the ear, and the eye. Relation and mutual respectiveness result from varieties, and one thing is distinguished from another thereby. For what is the pleasant apart from the idea of the unpleasant? What is the sweet apart from the idea of the bitter? What is the beautiful apart from the deformed? The warm apart from the cold? Nay, what is the true apart from the false, and the good apart from the evil? Wherefore, if the parts or modes of objects are becomingly connected, then by virtue of the relation of the delightful to its opposite, as we all know, the sensitive life wakens up and in a manner revives in the organs, however languid and sleepy they may be, and the intellectual life in the sensorial principles, although just before they were fainting and failing.

556. *The objects that imprint their image upon the papillary organ, or induce mutations upon it, are many in number, both bodies or substances, and accidents and modes, with their degrees and momenta; to wit, all things whatever that change and affect the natural state of the organ or its parts.* These objects comprise almost all the external accidents or predicates that declare

their existence and qualities by means of the senses, particularly of touch and sight, or which generate our first ideas; such, for instance, as the varied *configuration* of bodies; their *planeness*, *convexity*, or *concavity*; the differences of character in each of these conditions; the peculiar way in which bodies are *cornered*, *curved*, or *hollowed out*; or *obtuse*, or *acute*. But these particulars the organ not only perceives by its sense, but also explores by the aid of the muscles; for in order thoroughly to investigate the figures of the larger parts, the fingers are bent, applied, moved about to and fro, reciprocally pressed against the thumb, or conjointly make a palm or hollow in which they can grasp the subject under examination; or else they wander over it in some other manner, as use demands and habit has taught them; and wherever any resistance occurs, the precise reaction or mutation accompanying it becomes a matter of careful enquiry; or note is taken whether the object slopes downwards, or rises, or comes to an end. In this manner the fingers run over and examine globes, cubes, trigons, paralellograms, trapeziums, polyhedrons: and by a corresponding piece of natural skill we distinguish the *large* and the *small*; the *many* and the *few*; the *thick* and the *thin*; the *discriminated* and the *continuous*; the *near* and the *distant*; yea, and at the same time by muscular weighing and reaction, the *heavy* and the *light*. There are some objects, however, that display and represent themselves to the touch immediately, by an idea of delight, compliance, consent; for instance, *soft*, *smooth*, *flat*, *polished*, *lubricous* objects; and the contraries of these, by a feeling of undelight, resistance, dissent; for instance, *rough*, *hard*, *ragged*, *hirsute*, *chafing* objects. By touch moreover we take cognizance of *motions*, and even of *celerities* with their momenta, particularly when an object runs over spots that differ from each other in their sense of touch, the organ meanwhile being at rest. But *tremors* and *vibrations*, or the various kinds of *numbness* and *deadness* that are their opposites, are recognized by a certain correspondence, or similar species of activity or rest in the papillary fibres. The *hot* and the *cold*, with their degrees, are recognized by a real expansion or constriction of the parts of the organ; thus by properties similar to those that exist in heat and cold themselves. Heat excites the sense, because it expands

the fibres; cold takes it away, because it constricts them. The *moist* and the *dry* again, which are equally objects of touch, are recognized in a different manner; the moist, to wit, by fluidity, yielding, cold, or warmth, and by the refreshment of the dried skin; the dry, by the contrary affections, particularly in the little lips of the pores of the cuticle, which little lips are principally designed for the perception of moisture and dryness. *Fluidity* and *fixidity, liquidity* and *tenacity,* are recognized differently again. Furthermore, the very motions of the object upon the organ, or of the organ upon the object, according to the degree of their velocity, increase the play of these mutations; and in this way the *fall* of gravitating bodies is distinguished, and the gradations of the *influences* of heat and cold; consequently the *weather* and the *seasons.* Whether therefore they be quantities or qualities, they are felt by touch; this being the case with everything that exerts a stress upon the nexus of the parts, particularly of the fibres, in the organ; or influences their position, order, and series, so as to change and invert their states, properties, and functions (n. 529).

557. *In order that objects may be properly known, touch is instructed by sight, and* vice versâ, *sight by touch.* Touch and sight are as it were married partners; their union results in the conception and birth of an idea as an offspring, and when this idea grows up, it is called a reason, and ultimately an understanding. Sight is in a manner the wife, and touch, the husband; while hearing may be considered as a handmaid ancillary to sight as her mistress; and taste and smell as male attendants ministering to touch. The idea that is born to sight and touch conjointly, is the offspring of a legitimate bed; but the idea that is born to touch and hearing, (as in persons blind from birth,) is a bastard offspring, because begotten from the handmaid of sight. From the very life of the marriage of touch with sight, we clearly learn the sort of idea that is engendered by the conjunction of touch and hearing only; for instance, in cases of congenital blindness. For I. *Sight is instructed by touch* respecting what lies in objects beyond their external and accidental form; that is to say, whether they be *hard* or *soft, cold* or *hot;* which particulars are concealed from the eye, unless they are felt by the fingers: nay, until sight has been

informed by touch, it is not aware that live coals burn, and that ice freezes. Also, whether objects be *heavy* or *light;* which points touch explores by the steelyard of the fingers; while sight can only do the same by scales or other artificial means: so that touch apprizes its partner, sight, of the value or worthlessness of objects, as depending upon these properties; taking account of the weight of metals, minerals, and other precious things, and thereby ascertaining that they are not base materials, gilded, plated, or otherwise disguised, to give them a false appearance of nobleness. Again sight is instructed by touch whether objects be *rough* or *smooth;* for instance, whether any fabric be linen or woollen, cotton or silk; otherwise sight would judge from the mere shining or dullness of the texture,—from the mere effects of light or shade. Consequently whether objects be *phantoms,* which appear to live in dusk or twilight; whether they be *statues* and *pictures,* which when well executed might deceive Apelles himself, were it not for the sense of touch. Thus the one sense teaches the other to distinguish between the imitations of art and the works of nature: for this purpose touch is oftentimes sent out by sight to act as a general explorer. Not to mention *present,* or rather, *instant* objects, which either outrun sight, or steal away from it, but which touch makes manifest; particularly in the dark, when touch actually assumes the province of sight, and shews the way. II. *Touch, on the other hand, is instructed by sight* respecting *quantities* that do not fall within the sphere of the former; namely, that either exceed its capacity or sense, or that do not come up to it; such as the character and extent of woods, lakes, cities, palaces, houses; or of those minute objects that can be discerned only through the microscope. Also respecting *distant* things, and respecting the approach of tangible bodies, hence of danger; for if the blind leads the blind, they knock against each other, and both fall into the ditch. Particularly respecting the *agreements* and *harmonies* that result solely from discriminations of light and shade; consequently respecting the similitude between large and small bodies, however differing in magnitude. If then touch be instructed by sight respecting harmonies, it is also instructed respecting the *comeliness* or the *beauty* that proceeds from harmonies; respect-

ing the *pleasantness* that springs from beauty; and the *goodness* that arises from pleasantness; whence *love,* which is born by the continued series from harmony to goodness. But if touch is unmarried, or deprived of sight, it judges on these points from the smoothness, lubricity, polish, or yielding character of objects; as on the contrary points, from their roughness, ruggedness, and resistance: or if you please, the remark may be applied to the understanding formed of the ideas generated by touch and hearing conjointly. The truth of the foregoing considerations is clearly proved by the case of those, who not born to the enjoyment of light, have hardly trusted their sight when they gained it, but every time thought they were deceived by sight itself, until they made use of the intervention of touch (*n*).

(*n*) We read it proposed as a problem by Molyneux to Locke, [*Essay concerning Human Understanding,* book ii., chap. ix., sec. 8,] Whether a person blind from his birth, being made to see, could distinguish a globe from a cube by sight alone, through the mere variation of light and shade, without having recourse to the associate sense of touch? This question, they say, was at length solved by experience in the following manner. A person born blind, and who afterwards gained his sight by the operation of couching, was not able to discern magnitudes, distances, or shapes, by the distinctions of light and shade, unless he made use of touch as an assistant and interpreter to sight. Moreover, as they assert, he thought no objects so agreeable as those which were smooth and regular to touch. He was very much surprised, that those things which he had liked best, did not appear most agreeable to his eyes; thinking that what was the most pleasant and bland to touch would be the most beautiful also. Again and again he learnt the names of the animals that he saw, but as often forgot them, until he recalled them to mind by touch. Having frequently forgotten which was the cat, and which the dog, he was ashamed to ask the question, but consulted his most familiar sense, namely, touch, clandestinely. They also say that he was greatly deceived by pictures, expecting them to feel like the things they represented, or to express nature by art, and being amazed when he found that those parts which by their light and shadow appeared round and uneven, felt only flat like the rest: and he asked which was the lying sense, feeling or seeing? Being shewn his father's picture, he wondered that a large face could be represented in so small a compass; saying, it would have seemed as impossible to him as to put a bushel of anything into a pint vessel.

Thus these senses, like husband and wife, lend each other mutual aid, and the one with the help of the other, begets or conceives a legitimate offspring or idea. In order that the understanding that grows out of the ideas so conceived, may be persuaded that it is the child of this marriage, it requires to be certified of the fact from the mouth of both the parents; for when we can say, I have *seen and felt,* it attaches its belief.

558. *Besides the affections arising from external sensations, there are also affections from internal causes, which vary our senses, and touch particularly, in a singular manner.* The papillary substance of the cutis is extremely susceptible of changes from every slight affection. (n. 517). The very perspiration through the cutis takes place with infinite variety, according to all changes of state arising from sensation and affection, outermost, innermost, and intermediate (n. 513). There are external and internal affections; speaking generally, affections of the body, of the animal mind, and of the rational mind, each of these having its own: the affections of the body are those that change the state of the blood; the affections of the animal mind are those that change the state of the spirits; and the affections of the rational mind are those that change the state

At first he could bear but very little sight. The room he was in, he said, he knew to be but part of the house, yet he could not conceive that the whole house could look bigger. Before he was couched, he expected little advantage from seeing. And even blindness, he observed, had this advantage, that he could go anywhere in the dark, much better than those who can see; and after he had seen, he did not soon lose this power, nor desire a light when he went about the house in the night. He said that every new object was a new delight; and the pleasure was so great that he wanted ways to express it. He could not conceal his gratitude to his operator, never seeing him for some time without tears of joy in his eyes, and other marks of affection, &c. (See Cheselden, *Philosophical Transactions,* n. 402, art. vii., p. 447—450, an. 1728, and *Anatomy,* book iv., chap. iv.; and Robert Smith, *Compleat System of Optics,* book. i., chap. v., n. 132—134; and vol. ii., *Remarks,* sec. 161, 162.*)

* I have found it advisable to give part of this note in Cheselden's own words, in preference to translating it literally from Swedenborg, whose account is occasionally obscure.—*(Tr.)*

of the soul (n. 514, 515). How these affections modify the state of the papillary sensorium, or organ, consequently the sense itself, is best seen in examples. First with respect to the *affections of the body*, or specifically, with respect to its ailments and diseases, which as they change the blood, therefore also change its vessels, and the fabrics constructed by the vessels, consequently again the organ of the cutis, which is not only fibrous, but vascular; and therefore also the sense itself: for in the organ, as in a mirror, we may see the nature of the sense, and *vice versâ;* the one being exactly represented in the other (n. 548). Thus moisture is perceived differently by a dry skin, and by the same skin when moistened; heat is perceived differently by a cool skin, and by the same skin when warmed; differently, to wit, in essential, ardent, burning, and intermittent fevers respectively; differently in lipyria, in which the outward parts are cold, and the inward parts burn; differently in tympanitis and paralysis: in a word, differently in every preternatural state; as in extension, relaxation, induration, or obstruction of the skin; nay, where the skin is thinner, and denuded of the scales of the epidermis, the sense has an inverse play,—soft things prick it, smooth things tickle it, cold things inflame it, warm things burn it, &c. But with respect to the *affections of the animal mind,* these likewise modify the sense in various ways, and substitute for each other the ideas arising from the senses; for in anger and rage it [sense] is disturbed, in mirth it is shed abroad, in sorrow it is straitened, in venery it is kindled from the very innermost, in shame it is self-oblivious, in fear it is extinguished; to say nothing of the fallacies resulting from imagination alone. But the *affections of the rational mind,* which are still more internal, influence the state of this sense more frequently, and therefore more imperceptibly; for the rational mind may be either present in the senses, or absent from them,—it may in a manner infuse itself into them, or withdraw itself from them; whence states of attention or abstraction; which varieties appear particularly in the vigils of the rational mind, in its intuitions of ends, loves, inactivities, sleeps, cares, anxieties, and troubles, &c.

559. *Touch, like the other senses, does not indicate the essence, form, and nature, that objects have inwardly, but only that they*

have outwardly; consequently only their figure or external form; wherefore experience, art and study are necessary to explore these objects more thoroughly. External accidents are all that declare their existence and qualities by means of the senses, and particularly by means of touch (n. 556); for touch is the most obtuse and indistinct of all the senses (n. 550). It apprehends only that bodies are figured in one way in contradistinction to another, but does not apprehend what is hidden within their bark or surface; wherefore it the less instructs the understanding respecting inward things, inasmuch as all forms whatever may have any possible figure or surface given them. Nor is anything manifested by touch, beyond the softness, smoothness, or lubricity of the body presented to it, which are external accidents; but this sense cannot decide whether these properties belong to the body originally and essentially, for there is no object but may have similar properties given to it extrinsically by artifical means. Touch has no standard of worth or value whereby to judge of the objects that it weighs with the fingers, beyond simple gravity and levity. Nor does it so far distinguish the character of any fluid in which the fingers are dipped, as to discover whether it be purely aqueous, or whether it be lie, or decoction, or expressed vegetable juice, or urine, or the like: it only discerns varieties according to the degrees of thinness, thickness, firmness: but there is nothing in universal nature that may not be reduced by artificial means to any one of these conditions: wherefore touch explores nothing beyond the outermost surfaces of things. Thus the understanding is vastly deceived in those who depend upon their senses, and they are exposed to the danger of judging of internal by external predicates; to wit, of beauty by smoothness, of pleasantness by beauty, of goodness by virtue, of which love is insinuated, by pleasantness (n. 557). Therefore he that trusts to the senses alone, is readily induced to esteem an asp or a hydra for the mere smoothness of its skin, a panther or a tiger for the softness of its coat; as hearing esteems a siren for her song; taste, philters and poisons for their sweetness; sight, the vilest of harlots for her outward beauty and allurements, and not unfrequently companions themselves from the ground of pretended friendship, and counterfeited kindness. The mind has need of

sciences that can scrutinize inward things, lest it should put its trust in the like delusions and wiles; and all the sciences, therefore, both empirical and theoretical, are so many signs of the deceptions and fallacies of our senses, proving, that they do not indicate the essence and nature that objects have inwardly, but only the essence and nature that they have outwardly; that is to say, their figure or external form. For before we can know what is involved in foods, vegetable juices, herbs, and flowers, be they ever so delicate and fragrant, we have to experiment chemically, by means of menstrua, fire, and different modes of operating; and medically, by trials upon living bodies.

560. *Each papilla, which represents a unity of our touch, consists of fibres, or simpler papillæ; consequently each unity of our touch arises from other most minute [unities].* The papillæ that rise through the foramina of the corpus reticulare, represent the unities of our touch (n. 549); and as these are of sufficient bulk or dimension to be visible to the naked eye, they are of course made up of innumerable fibres and vessels, or more minute types, and covered with a kind of continuous tunic, so as to present the appearance of a single and simultaneous body (n. 505). All who are accustomed to use the microscope know that such is the fact: for in proportion to the power of the lens that is placed between the eye and the object, or in proportion to the smallness of its field, in the same proportion we penetrate further into the grounds and lines of simpler corpuscules; and those that still appear indistinct and confused, may, by the application of a finer lens, be brought out of their obscurity into still greater distinctness; and so on: shewing that the sensorial papilla of the cutis, which is large enough to be seen by the naked eye, when broken up and examined by the microscope, displays an entire fibrillary grove, entering into it and constructing it. For when the cutaneous nerves advance to this boundary of their kingdom, and unfold their fascicles into the primitive fibres, they then for the first time go to compose these their organic forms; in the same manner as the rest of the nerves when they come to any other goal or unity; for instance, either to a gland, or a cell, or a moving fibre; for when any one of them is contemplated by

the microscope, it displays wonderful ramifications. So much for a general view of the subject. With respect to the papilla of the cutis specifically, the fact that it is constructed of manifold fibres, and even of most minute vessels, is clearly shewn by its softness, by its yielding to the least force of touch, and by its changing in correspondence to every spark of affection (n. 553); consequently by its expansibility, contractility, its proneness to relapse into its pristine state, and the constancy wherewith it regains its natural state: this cannot be owing to the papilla as a compound; but to the fibres of which it is composed. Again, the same thing is proved by the immense number of pores in the commissures of the papillæ, which pores are opened and shut with the greatest readiness, to meet every condition of change arising from affections of the body, of the animal mind, and of the rational mind (n. 513, 517): but unless these pores were made of the purest fibres, put forth from the bosom of the papillæ, they could never obey so constantly such vast varieties of affections, as the phenomena of the Sanctorian perspiration shew that they do. From these considerations it is evident, that each papilla exists from simpler fibres, for every compound is but a congregation of its simpler elements, and a sum of the same put together upon the model of use (n. 541). The reason why the unity is such a cause as it appears to be, is contained in the fibres and vessels of which it is composed (n. 538). Thus the papillary organ of touch, like other organic forms, ascends to its third dimension before it completes its determinations (n. 533).

561. *From these fibres, which are the parents or unities of the papillæ, the sense of touch derives its distinctive generic character.* The parent fibres of the papillæ are not bare fibres, like those that are detached directly from the nervous bundles, but exquisitely fine organic textures, fashioned by those fibres upon the model of use, that is to say, so fashioned as to give birth to this sense; for the reason why a unity is a distinctive cause, is contained in its form (n. 538). Unities are the essential determinations that construct the form of the whole, or the common form; but fibres with vessels are the essential determinations that construct the forms of the unities, or the particular forms (n. 539). For the fibres that have just come from

their nerves, are the universal creators of all the roots or stocks from which the organic vegetations in their wonderful diversity proceed; some, to wit, to serve for touch, and some to serve for taste, or for smell, or for some other function. For example, in order to the existence of a vesicle that can draw in and send out the breath or spirit of the lungs, it must be so constructed of fibres and vessels as to possess this use in its nature. Likewise in order to the existence of a gland that can lustrate the blood or chyle in the liver, it must be of such a class, as to contain this use in its form or fabric (n. 538). Precisely the same is the case with the parent fibre of the papilla of touch; in order that it may be distinct in nature and sense from the papilla of taste and smell, it is necessary that it be inaugurated into its own sense from its first condition or stamen. Touch is different in nature and character from taste and smell; this being proved by the origin, degree, effect and use of each, as well as by the evidence of our own feelings (n. 524). Inasmuch then as the first web or form of the fibres is the initiament of the destined function, it follows that this web or form is the unity of its compound; therefore homogeneous [with it]; for the compound grows out of its unities (n. 538, 541); and is like a number or sum, which involves nothing but such unity congregated and multiplied in divers forms: indeed, it is contrary to nature herself for heterogeneous parts to be ranked together, since they do not agree in simple ratio, still less in a series or proportion of ratios. Different kinds of seeds or roots never unite to form one tree or one flower, and so fibres of different kinds never go to produce one sense. By reason of this affinity, and agreement from the very stock, these fibres are papillæ in the least form: for unities and compounds, as similar types, stand related to each other, and shew themselves to be of one genus, in their power and manner of acting (n. 536, 541).

562. *The objects of touch induce mutations not only upon the common series or form of the papillæ, but also upon the parent fibres of each papilla; and in fact more considerable and distinct mutations in proportion as the organic forms are more perfect.* The very connexion and communication of the external parts of this organ with the internal, shew abundantly the nature of the influxion of the mutations arising from objects or impres-

sions of objects, towards the innermost sphere, or into the very organic texture of each papilla. For such is the union and perpetual mediation of the scale of the epidermis, the corpus reticulare, and the cutaneous pores, with the surface or little tunic of the papilla, and of this again with its innermost fibres, that the common vibration or modification of the parts necessarily flows in and penetrates towards the deepest or innermost sphere, or to the parent fibrillæ of the sense, and changes or disturbs their position, order, and connexion (*o*). That the entire papilla with its bundle or wedge of fibrillæ, undergoes a considerable change from every touch, is apparent on general grounds from its pyramidal or perhaps globular form, when it is seen in its natural state (*p*): for when the squamous plate is pressed, the papillary globe or pyramid underneath it must necessarily be thrust inwards, and forced to assume a different form from that which is proper to it. But let us examine the connexion of the parts, and thereby the mediation of the outermost with the innermost. It was shewn above, from anatomy, that the scale of the cuticle is connected by fine filaments or vessels, not only to the corpus reticulare, but also immediately

(*o*) It is a common and most familiar rule in every organ and viscus of the body, that determinations flow, or what amounts to the same thing, that fluxions are determined, from the outermost sphere to the innermost, and from the innermost to the outermost; or from compounds to simples, and from simples to compounds; or from the greatest things to the least, and from the least to the greatest; as proved above, n. 540. I am now about to shew how the same thing takes place in the papillary organ of the cutis.

(*p*) The generality of anatomists assert, that the cutaneous papillæ are pyramidal forms. They are so described by Heister, Malpighi, and others, and delineated by Ruysch and Bidloo [n. 521, *o*]; because they appear of this figure when they are extruded through the foramina of the corpus reticulare, and when they are erected spontaneously to receive sensation. Nevertheless, anatomists are not yet, I think, agreed as to what is their natural shape. "These papillæ," says Winslow, "differ very much in figure and arrangement in different parts of the body. . . . They are for the most part flat, [and] of different breadths. . . . The pyramidal figure generally ascribed to them is not natural," &c. (n. 473).

to each subjacent papilla; so that when the scale is forced in by a touch, and again raised, the surface of the papilla cannot but undergo the same sort of mutation (*q*). The corpus reticulare is likewise attached to the papilla, and at the same time to the scale, by capillary vessels continued from the papillæ; so that when this reticular substance is displaced ever so little, the whole surface of the papilla must necessarily partake in its motion, and reciprocate the same (*r*). Equally so if any pore is the subject of contact, either in its little mouth, or in any other part; for the stamina that construct the pores are drawn forth from the very bosom of each papilla (*s*). From these considerations it follows, that such is the perpetual conjunction and union of the surface of each papilla, with the scales, the corpus reticulare, and the pores, that nothing can invade the one without instantly invading the other also. But with respect to the internal fibres of the papilla, it is evident from an integral survey and evolution of organic forms (*t*), that such is the con-

(*q*) The reader will find this explained above where we treated of the epidermis; to wit, how it maintains the connexions of the parts spread under it; sustains their changes of state; and impels them to perform their offices aright (n. 490). Also, how it puts together the primal singular modes [of sensation] of the fibrillæ and papillæ, into a kind of common mode that is termed the sense of touch (n. 494).

(*r*) This also was proved by anatomical evidence in treating of the corpus reticulare: to wit, that the corpus reticulare serves as a link and instrument of union between the cuticle and the papillary substance; and as a mediating organ, and as an organ for transferring the modes, actions, feelings, and changes of the parts to the papillæ, and from the papillæ, on the other hand, to the scales of the epidermis or cuticle (n. 497). And how it is specifically connected to the papillæ. (*Ibid.*, note *d.*) And it causes everything to refer itself to a general; to flow backwards and forwards in a certain gyre; and to conspire and tend to its equilibrium and rest (n. 499).

(*s*) The pores have arisen from the fibres of the papillæ (n. 503). Unless these pores were made of fibres put forth from the bosom of the papillæ, they could never obey so constantly such vast varieties of affections, as the phenomena of the Sanctorian perspiration shew that they do (n. 560). Respecting the variety of affections that induce changes in these pores, see n. 513—518, 552, 553, 558.

junction between the surface, or the common proper tunic, and the interior parts, that as the surface is drawn different ways by an assailant external force, so also is every fibril that forms part of the heap within the surface; for ligaments proceed from the common tunic, that bind every fibril, and tie it down to the common service. Such is the nexus in all the nerves, in all the muscles, in every moving fibre of the muscles, in all the large viscera, and in all the lesser parts of each. Thus the tunic of each papilla, which appears to be vascular, communicates every detail of touch in the most distinct manner to the several parent fibres of the same papilla (*u*). These connexions are evident to sight in the papillary organ of the cutis, but they are still more evident in the sense itself in the other organs of which we shall speak in the sequel. The same thing follows again as a matter of rational induction; for if compounds are aggregates of simples (*x*), then of course the common mutation itself, which is analogous to the compound, is also a collection of simpler mutations, or a sum of least unities; consequently the common sensation that results from the papilla as a unity, is the coalescence and union of simpler sensations: for which end, indeed, all this binding together, or mediation by bonds between the scales, the corpus reticulare, the pores, and the surfaces of the papillæ, and between these and their parts, is instituted. It is also a necessary adjunct or attribute of each sensorial organ, that its innermost parts exquisitely perceive every mutation

(*t*) Bodies, viscera, members, and organs, are conjoined by bonds; the unities themselves, by theirs; the series proximately derived from the unities, by theirs; finally the composition itself, or the whole; which is covered with a coat, as the bond of all, or the common bond, from which the little coats and bonds of the other parts proceed, whereby the parts are bound to the common service, and live in a harmonious division of labor (n. 534). How this obtains in the nerves, the muscles, the liver, &c., and likewise in the papillary organ of the cutis. *(Ibid.)*

(*u*) How determinations are instituted in organic forms, and according to the determinations, fluxions from the outermost to the innermost, and *vice versâ* (n. 540, 552).

(*x*) As demonstrated above, n. 541 *ad fin.*

coming from without (*y*); in order that the general sensorium may drink in these distinctions by its organ, and thus be thoroughly aware of everything that is done in the ultimate sphere. In proportion then as these first sensorial fibres, or parents of touch, are delicate, in proportion as their order and connexion is proper and becoming, in proportion as they are free to act according to their form, and yet are unanimously devoted by bonds to the common use, in the same proportion they receive mutations with promptitude and facility. For organic forms are perfect, in proportion as their parts are placed distinctly with respect to each other; but yet concur unanimously to produce common effects (n. 535).

563. *We may see by calculation how many myriads of mutations constitute one particular of touch.* For the purpose of computing these myriads, let us assume the calculation of Leeuwenhoek; that 125,000 of the pores or exhalant vessels under the little scales of the epidermis, open in a space that may be covered by a single grain of sand (*z*). Multiply this number by the fibres and vessels that are woven or wound to form the canals and little lips of these pores; and again by those that fill the little frame of the papilla, as well as by the vessels on its surface, and by the bands detached therefrom. Add to this sum the stamina that enter the contiguous parts of the corpus reticulare, and the contiguous parts of the epidermis; for those stamina are continuations of vessels that creep up from the inferior and superior plexuses, and cover the papilla with their

(*y*) For touch is commonly excited by contiguous objects that strain the connexion of the parts, and especially of the fibres, in the organic body; or influence their position, order, and series, and thus change and invert their states, properties, and functions (529, 556). Our general sensorium is laid in the cerebrum; but the organ of the body acts the part of an instrument only; and the cerebrum perceives, that is, feels mutations, by the organs of the body (n. 528). The process by which impressions produce mutations, and these, a perception in the general sensorium, and so on (n. 552).

(*z*) According to Boerhaave, there are "exhalant vessels under the little scales of the epidermis, opening obliquely, and of such exceeding fineness, that Leeuwenhoek reckons that 125,000 of them open in a space that may be covered by a single grain of sand" (n. 479).

extremities (*a*). Add to these again the whole multitude of stamina and vessels that are spread under the papillæ, nay, that are inserted into the cutaneous glands; for they all yield when any single papilla or little papillary series is touched. Now multiply this aggregate, which will be sufficiently large, by the fibres that construct and produce those vessels and filaments; for everything springs from fibres. In the last place reckon up the amount, and see what the sum is. Well, we shall find it so large, as not to admit of being expressed by numbers, but only by myriads; nay, when the myriads themselves are made into unities, these unities must a second time be reduced to myriads, before the understanding can comprehend the sum resulting from them; and this if only a point of skin equal in extent to one grain of sand, shall have been touched.

564. *The mutations that exist among the fibres in each papilla, give the real essence and life that there is in this sense.* The least fibres that conceive and engender each papilla, are what give *esse* and *posse*, or essence and potency, to the papilla, as a compound; consequently are what give it the possibility to act and to suffer, or impart to it the power of acting and suffering: if this be the case, it follows, that they are really also what enable it to feel, or to live by the sense of feeling; for the papilla possesses nothing of itself that it does not derive from its primitives (*b*). The fibres afford the means of induction re-

(*a*) The corpus reticulare and the epidermis are a production from the ultimate ramification of the arterial vessels (n. 497, *d*). Respecting the scales of the epidermis, Heister says: "Even Ruysch, with his finest injections, was never able to discover vessels in the [scales of the epidermis or] cuticle, nor has any anatomist since his time succeeded in demonstrating them. . . . Although of course . . . [the epidermis] must be nourished and reproduced by a subtle fluid of some kind (n. 470).

(*b*) As follows from the conclusion at which we before arrived; namely, that compounds are the aggregates of their simples or unities (n. 541). But the papillary series, or the congeries of the papillæ, derives from its form the distinctive character that we see it to possess; but a papilla considered singly, or in itself, equally derives this from its form,—from the form, namely, determined by its fibres; such is the source whence essence and life accrues to each papilla. But the

specting the sense itself; for in the papillary organ of the cutis, as in a mirror, we may contemplate the sense of touch, and see the nature of that sense; and *vice versâ:* the one being exactly represented in the other (n. 548).

565. *These mutations that exist within each papilla, are most distinctly presented to the soul, which alone gives the power to feel; and this, according to the organic form in which the soul has disposed and combined the fibres and papillæ.* It is plain from what has been already shewn, that these myriads of mutations existing within the unity of the sensorium, that is, within each papilla, with their various and distinct modes, do not reach our general sensorium, or as it is called, our consciousness; for the papilla is the unity or least of that sensorium (n. 549). The same truth shines forth from each of the other senses; for example, from sight, in the least ray of which there lies such an infinity of objects, images or parts, that the eye cannot but itself acknowledge and wonder at its own darkness and blindness, as soon as ever a microscope is called in aid; for what appeared to it previously as a dim and obscure point, is now seen to comprehend infinite parts, joined in the most beautiful order; perhaps to be an entire living body with all the organs and members that exist in a large animal. Likewise from hearing, taste, and smell. These innumerable, and, to our sensorium, imperceptible mutations, cannot but refer themselves to some intimate sanctum in the sensoria, or to some principle, that is the first, the highest, the simplest, the most remote, and the sole,—to a principle in which life is involved, and the force and life of which all other things carry out and live, and which causes the sense itself to be and to live: this principle is what we term the Soul. But the truth is, that before we arrive

essence and life that is involved in the sense of touch, (not in each unity thereof,) results from the entire organ, in which the papillæ are regarded as unities. The reader may see these particulars proved in detail above. Thus: the sense of touch derives its distinctive generic character from its fibres (n. 561). Unities are the essential determinations that construct the form (n. 539). Unities also are the first efficient causes of effects, and the determinant causes of uses: but the reason why the unity is such a cause, is contained in its form (n. 538).

by analytic investigation at such a height, as to allow us to represent to the life what the soul is, (which we hope ultimately to do,) and to shew that it is an essence so real, that it is the only essence by which we live; and that it is absolutely distinct from its and our intellectual mind that is instructed by the external senses,—before this is the case, it must appear like an obscure enigma when we declare, that these innumerable mutations, with their momenta, degrees, successions, and varieties, are not referred to the general sensorium, which is *our innermost*, but to that sensorium which is *the innermost of ours*; in a word, to the soul; and are perceived distinctly by it alone. For it is a fixed and certain truth, that our sensorium or intellectorium imbibes, as a single thing, nothing short of myriads of mutations taken collectively; and that into this single thing is infused by a higher and inner principle, that which lives in sense, or which is the soul of sense (n. 564); and that, inasmuch as it penetrates thither, it is called a sensation, and perceived and discerned by our general sensorium. For this is proved by everything that takes place in the cutaneous circumference, and everywhere else in the universal body. *From these considerations it is manifest, that the sensorio-organic form of touch is twofold; namely, one form simple, the other compound; and that the compound arises from the simple: but yet, although the form appears double, it is nevertheless one in this respect, that both its elements together produce this sense. Also that the simple or fibrillary form immediately refers its modes of sensation to nature, or to the soul, in which that nature is involved; but that the compound or papillary form immediately refers its modes to the general sensorium, or to our understanding, to which such sensorium is assigned.*

566. *The soul has so organized the body* (c), *that it* [*namely,*

(*c*) In my *Economy of the Animal Kingdom*, tr. i., n. 253—270, it was proved by a great number of considerations and by much experimental evidence, that "there is a certain formative substance and force, that draws the stamen or thread from the first living point, and afterwards continues it to the last point of life; of which substance and force, from defect of terms, scarcely anything can be predicated adequately, excepting that it is the first, the most perfect, the most universal, and

the soul] is conscious by means of the senses, and by means of touch particularly, of whatever happens in its extreme, that is, outermost and innermost spheres (d), as well as in its intermediate sphere; in order that from the first moment of bodily life to the last, it may keep all and singular things under its auspices, and dispose them according to contingencies. The simplest or first fibres, from which the compound or true nervous fibres are derived (*e*), are the universal and principal determinations of the forms of the whole body (*f*); for everything that exists is framed of fibre. Wherever there is a fibre, and a tactile object that moves it, there also there is the sense, which is properly called touch (*g*).

the most simple, of the substances and forces of its kingdom; and that this most real force and substance is the soul."

(*d*) It was demonstrated in Part II., p. 284, 285, n. 440, (*b*), that both the innermost and the outermost things are the extremes of the fibres. For such is the mode of circumgyration and circuition in the organic body, that those things that are outermost, go towards the innermost, and that the fibres place their ultimate goals in both these spheres. Thus the innermost membrane of the pleura becomes the outermost membrane of the pericardium; and the same occurs in other parts; for what is the innermost in the stomach is the outermost in the tongue, as evidenced by the papillary membranes of the stomach and tongue.

(*e*) I intend to demonstrate in the Part on the Fibre, that the fibres seen with the microscope in the nervous fascicles, are not the first-born, but are formed of simpler fibres. This is plain enough from the single circumstance, that these fibres are most fine canals, as proved to ocular demonstration, and consequently are surrounded with a little tunic; which little tunic must derive its origin from simpler and prior fibres. Thus we may call the latter fibres simple, but the former compound, or genuine nervous fibres.

(*f*) Unities and continuations of unities are the essential determinations that construct the form of the whole, or the common form; but fibres with vessels are the essential determinations that construct the forms of the unities, or the particular forms (n. 539—541). And the fibres are the universal determinations. (Part I.; p. 487—489, n. 313, 314.) Respecting the simple fibre and the nervous fibre, see *Ibid.*, p. 489, 490, n. 315 (*k*).

(*g*) Touch is commonly excited by contiguous objects that strain the connexion of the parts, and especially of the fibres, in the organic

In the whole of this body or system constructed principally of fibres, there is no point, still less any conglobation of points, lines, or areas, that is not pressed, and rubbed or chafed incessantly, by some fluid and active object. The vessels, even the capillaries, are so treated by their blood and serum; the lacteals and lymphatics, by the chyle or lymph; the pores and passages, by some humor; the glands and cells, by the essences that fill and flow through them; in like manner the other recesses and openings, small and large. No vacuum or empty space exists, for this would cause the part to collapse and perish. Therefore we nowhere find any little place or space, where some fibre is not touched, and the principle of the fibre admonished by the touch (*h*), whether this principle be in the cerebrum, or in the cerebellum. These are the signs and proofs, from which the innermost sensorium, (where the soul resides, or over which it presides,) is instructed respecting the state of the body, and of each of its viscera, and affected correspondently; and thus is excited to concurrence, or to render assistance; whence the disposition, out of which arise the effect and use that touch produces (*i*). From this modification in the

body; or influence their position, order, and series, and thus change and invert their states, properties, and functions (n. 529, 556). Not only in the papillary cutis, but in every fibrous texture whatever (n. 530). Nay, even in the other organic sensoria (n. 525, 530). But the touches made internally in the viscera do not arrive at the perception of the general sensorium (n. 527).

(*h*) In all, even the very least, recesses and spaces, there is some humor or volatile vapor that permeates and flows round them. (Part II., p. 269, 270, n. 433, *a*.) The principle of the fibre is aware of all that befalls the fibre in both its extreme and intermediate parts: see n. 526, where it is shewn, that in touch we have a type of that sensation by which the viscera are affected in their innermost parts, particularly the viscera of the abdomen, as the œsophagus, the stomach, the intestines, the ureters, the bladder; where similar papillary fibres are seen, which are pressed by tactile objects of a not dissimilar character.

(*i*) According to what was shewn above; namely, that in touch, as in all the other senses, there is first an impression, involving in it an action; next a mutation answering to the impression, and a reaction

structures, and from its own affection corresponding thereto, the soul, as we before said, is instructed respecting objects, as to their particular character and fitness relatively to the blood and the spirit; and in fact, in the little mouths of the pores of the skin, respecting the ethereal elements, that fly thereto in abundance, and come in contact with their delicate little lips; and which, if they are congruous and kindly, it catches up and lets in; but if incongruous, spits back and repels (*k*): and it disposes those pores suitably to every necessity and demand of the body; as clearly proved to us by the phenomena of the perspiration; the causes of which phenomena are utterly hidden from us, because this very sense itself is utterly hidden. The same is the case in the stomach and intestines, where exploration is made by an analogous touch, as to what there is of useful, and what of injurious, in the parts of the food; as to the quantity and powers of the salivas; and as to the condition of the chyle, which is worked and rolled until it is sufficiently pliant and round (*l*), and the touch of it will no longer provoke and irritate the fibre, or the little lips of the pore into which it is about to be received. That there is a perpetual advertence or sense of the kind, is evident from the very frequent changes that these viscera undergo, in correspondence to the character of the food they receive, and of the humor that flows through them; which changes would, in fact, exist without a cause, if without a sense like this: not to mention the other organs and viscera, which while they live under an analogous sense, live

corresponding to the action; then a perception of the mutation; forthwith according to the perception, an affection; according to the affection, a disposition to the preservation of the part or the whole; then an effect embodying the use that the sensation, namely, touch, produces (n. 552).

(*k*) The aliments that serve as nutriment to the spirit and the blood, are insinuated through the cuticular pores (n. 492, 493). And those most pure aërial and ethereal aliments that wash against the little mouths of the subtlest pores, are either admitted or repelled, according to the bidding or advice of a certain occult sense (n. 504, 509).

(*l*) The particles of the chyle are round and globular, and not rough and angular, and therefore cannot irritate the fibre. See the citation from Leeuwenhoek, Part I., p. 115, n. 90.

under the auspices of the soul, omnipresent by means of this sense; and all of which, in general and in particular, enter into, and take upon them, an infinite variety of states (*m*), corresponding exactly to objects, which are to be treated either gently or harshly, to meet every requirement of use. From this ground all the innumerable species of appetites, dislikes, desires, affections, and even of instincts, derive their occult origins; as consequently does all that mysterious and wonderful play of operations that is commonly ascribed to nature: yet what is nature but a dead thing, that only serves life as an instrumental cause, absolutely subject to the free direction of an intelligent Being, who uses it to advance ends by means of effects (*n*)? wherefore to attribute life to nature, or what is the same thing, to place the vicissitudes and forms of living organs under the auspices and government of nature, is a contradiction in the very object or adject.

567. *If any particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life.* For the soul has so organized the body, that it [the soul] is conscious by means of sense, and by means of touch particularly, of whatever happens in its extreme and middle spheres; in order that it may keep all and singular things under its auspices, and dispose them according to contingencies (n. 566, 529). Wherefore sense is the proof of life, and of the union of the body with the soul, and the sign that a member is conjoined in society with others, and bound to the laws of that order which the soul has instituted and constantly maintains. For if a part is loosened from its bonds, it no longer acts in consort, or in the end which conjunction is designed to serve; and thus does not communicate with the principle of the fibre, or derive the laws of its office therefrom: hence it is not present in the idea and intuition of the universal essence, and therefore is not taken care of by it, but wanders like an alien whither chance carries it, and so in no long while is consumed, wastes, is disjoined,

(*m*) Respecting the changes of state that the viscera undergo, see above, n. 490, 513—517, 537.

(*n*) The reader may see this explained more fully in my *Economy of the Animal Kingdom*, tr. ii., n. 234—238.

and at length is rejected as dead. This is certain from an actual inspection of parts, which after being displaced, deprived of sense, eroded, or having in any other way escaped from the common bond, as in gangrene, sphacelus, cancer, are in a short time cast out of their own borders and kingdom, as burdensome and putrid.

THE USE OF TOUCH.

568. The uses of the sense and sensorium of touch, are, I. *To perceive all changes of state occurring in the circumambient world, and communicate them to us: and thus to keep both watch and ward; to notice whatever happens, and by means of its organ placed on guard, to protect, at the same time that it institutes communications.* The atmospheres of the circumambient world lie incumbent upon the animal microcosm; and press all points of its body with a force and weight proportioned to their column: the papillary substance of the cutis sustains in the first instance the incumbency, gravity, and force of the atmospheres (n. 485, 491). It likewise receives in itself in the first instance all the changes of state in the atmospheres,—their heat, cold, dryness, moisture, in all their variety, their partial motions [and general perturbations], and communicates them to us by means of touch (n. 485). The cuticle, like a coat of mail, protects the sensitive, soft and agile tunics that it covers in, against injury from the surrounding air, against its heat, cold, perturbations; and moreover against the rough and stinging particles of its vapors, and of different fluids (n. 491). And takes upon itself in the first instance the changes that will arise in the body from the world, tempers them, and tends to break their force (n. 491). It institutes the proximate communications between the circumambient world, and the corporeal world that it encloses (n. 492). It sends out obsolete volumes of effluvia, and sweats consisting of useless lymph and rancid fat, and disperses them into the contiguous air (n. 493). It also sucks in the same, and insinuates them into the new formed veins (n. 506).

569. II. *To announce to the understanding whatever comes in contact with, assails, or beats against the skin; what it is, its quality and quantity, and where it comes from; so as to allow that faculty, from the evidence of the impression, to judge of what is intended; and at the same time to put the body either in a state of protection, or in a way of taking advantage of the thing, and receiving benefit from it.* Our general sensorium is laid in the cerebrum, which feels; but the organ of the body acts the part of an instrument only. The cerebrum manifests to us whatever it feels and perceives from the organs of the body (n. 528). For in the organ of touch there is first an impression, involving in it an action, either from some inert, or from some active force, that comes from without. Next, answering to the impression, a mutation in the excited part of the sensorial organ; and hence a reaction corresponding to the action. Then a perception of the mutation in the general sensorium, giving rise to a sensation. Forthwith, according to the perception, there arises an affection: according to the affection, a disposition to the preservation of the part or the whole; or a change of state in agreement with the affection: then an effect embodying the use that touch produces (n. 552). The objects that imprint their likeness upon the papillary organ, are many in number; to wit, all things whatever that change and affect the natural state of the organ or its parts (n. 556).

570. III. *Touch also admonishes the organs of taste and smell of the existence, quality, and quantity of that which is either taken in openly, or glides in furtively, and which those organs are shortly about to explore in a different manner by their senses.* Touch is present distinctly in the organs of all the other senses, and governs in a general manner as it were with them as companions (n. 525). Nevertheless these senses are different from each other in nature and character; this being proved by the origin, degree, effect and use of each, as well as by the evidence of our own feelings: they are in fact so widely distinct as never to approximate save in absolute obscurity (n. 524). Every sense derives its distinctive generic character from its parent fibres or unities (n. 561). For in the organs of the other senses, and particularly in those of taste and smell, or in the tongue and the nares, touch is as it were ensign-bearer, and

announces what is hurtful or profitable to them, or what calls forth or impairs their general power; and this is the reason why touch is so exquisite in the edges of the lips, which are to receive the future objects of taste in the first instance; and in the cavities of the nares (n. 525), which are similarly to receive the future objects of smell. As for taste specifically, it perceives, or explores by its sense, only the forms of parts in solution, that is to say, the accidental forms of parts, but not quantities, as *large, small, many,* and *few,* which even in the tongue itself are the objects of touch (n. 556); which sense indicates to the tongue how its proper sensation, or power of feeling or tasting, is varied by those objects. For taste is simply blunted by large objects, sharpened by small, overwhelmed by many, and diminished by few. Nor does the tongue perceive by taste, but by touch, *mobility* and *quiescence, moisture* and *dryness;* for the papilla of taste is simply excited by motion, made languid by rest, brought into erection by moisture, and contracted by dryness. Again the tongue feels *heat* and *cold* by touch and not by taste; for its power is simply wakened up by heat or warmth, and benumbed by cold. Thus touch indicates to the tongue, and its sensorium of taste, the existence, quality, and quantity, of that which is either taken in, or glides in, and which the tongue is shortly about to explore in a different manner by its sense.

571. IV. *That those which appear to be the ultimate qualities inherent in things, may be known, and be denominated, according to this sense, and its perceptions and affections.* For hot and cold, rough and smooth, even and uneven, jagged and polished, hairy and bald, solid and fluid, dry and moist, hard and soft, tremulous and torpid, are known by, and denominated according to, this sense; as well as many other things, of which without sense there would be no perception; without perception, no affection; without affection, no knowledge; and without knowledge, no naming or denomination. And this is the reason why the formulæ of a number of words involve something from some of the senses: and frequently, according to the nature of the sensation, or of the affection arising therefrom, these formulæ are expressed by words corresponding in sound with the thing signified, or enunciated by accent, either acutely or gravely,

thinly or thickly, smoothly or roughly: particularly according to the sensation of touch, which, assisted by sight, has a wider sphere, and extends to more numerous and more general things, than the other senses. But the above-mentioned predicates belong to the sensorium, but not to touch itself; the proper predicates of which are pleasantnesses, soothings, titillations, unpleasantnesses, pains, and the like. But the qualities that are explored by this sense, are only the ultimate qualities that appear inherent in things; for touch does not indicate the essence, form, and nature that objects have inwardly, but only that they have outwardly; consequently only their figure or external form (n. 559).

572. V. *To announce to the soul the subtle particles that wash against the little mouths of the pores of the skin, and that will serve as aliment to recruit the organic principles, and therewith the higher life of the body.* The cuticle institutes the proximate communications between the circumambient world, and the corporeal world that it encloses; that is to say, it admits from the air and ether comparatively pure, simple elements, which are in harmony with the natural state, and sends them down, as new aliment, into passages that lead to the blood (n. 492). The pores of the first kind have their origin from the first composition of the cutaneous fibres; their function is, to suck in the purer elements of food from the air and ether, and to carry them to their ends, and expend them upon the uses of life (n. 504). These pores immediately convey the elemental food that they sip from the ethereal and celestial auras, through their corporeal, thus venous, fibres, to the cortical glands of the brain, which are the prime laboratories of the spirits (n. 509). From these considerations it is perfectly clear, that the ultimate sphere, or the sphere of the body, subsists and is nourished entirely by aliments taken from the bosom of the earth; but the supreme sphere entirely by ethereal provisions and celestial food, liberally and largely supplied through the exquisitely delicate mouths of the cutis: hence that our purer, superior, and more excellent part is constantly supported and recruited from heaven, although so long as it is in connexion with the body, it is not aware of the high food on which it feeds (n. 519). For the mutations that exist within each papilla, among its fibres,

are most distinctly presented to the soul, which alone gives the power to feel (n. 565). For the soul has so formed its body, that it [the soul] is conscious by means of the senses, and by means of touch particularly, of whatever happens in its extreme, that is, outermost and innermost spheres, as well as in its intermediate sphere; in order that from the first moment of bodily life to the last, it may keep all and singular things under its auspices, and dispose them according to contingencies (n. 566). Therefore if any particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life (n. 567).

573. VI. *That the parts, and the series constructed of parts, or the members, may be excited by the irritation of touch, both to undertake and go through their functions.* The potency of corporeal life requires to be excited by sensation, before it can act and live in the shape of force; for potency alone has no results. Thus when we are excited by sense, we live in act, and this, according to the manner in which the organic forms are determined by the fibres, and in which the latter are mutually connected together, and correspond in general and in particular to the objects that are to be received (*o*). We contemplate this

(*o*) To explain this more clearly, for the sake of avoiding the hallucinations that as a thing of course proceed from obscurity, I will illustrate the matter in a few words, and by examples only. So long as any organ, as in the present case, the papillary organ of the cutis, is not excited by some object, it remains constantly in a state of potency, or of ability to develop sense, as soon as anything impels and excites. For all things that live in the body are formed with a power of acting, or of living in action; and do not enter upon their tasks and functions, until objects present themselves, knock at the door, or flow in. But it is not enough that the fabrics be thus determined by their fibres, and that these fibres be mutually connected with each other, and correspond in common and in particular to the objects: in addition to this, *there must constantly be involved, or continually be influent, a power from above or within, and at the same time from below or without, in order that the organ may be in a state for receiving, and applying to itself, that which is offered and represented.* Let us take the eye as an example. Unless the power of receiving images flow into all its fibres, and into all the minutest stamina of the retina, from the innermost;

in the sensorial organs; for the tongue is roused to its life, motion, and function, by edible substances; the nostrils, to theirs, by fragrant odors; the ear, by tones and musical notes; the eye, by images; and the papilla of the skin, by objects that rub against it. The same rule holds good in the viscera of both regions. The trachea and the lungs are excited by their air; the heart, by its blood; the œsophagus, stomach, and intestines, by their food, salivas and juices; the kidneys and the bladder, by their urine; the conglomerate glands, by the

and unless at the same time a light that enlightens the whole, flow into its common fabric from the outermost, the images that present themselves by variation of light and shade, cannot possibly be received, discriminated, and at length perceived. And a similar influx is requisite from within and from without into our organic principles, where the rational sight exists. These principles remain in mere potency, until a certain rational light, or life, flows in from the soul, or from the innermost; and a certain fire of life, passion, or love, (which are the stimulants of corporeal life,) from the body, or from without; in this case the objects that insinuate themselves either by ocular sight, or by the memory, fall distinctly into the understanding. The organ of touch is similarly kept in the power of feeling by internal and external causes: the internal causes reside in its least fibres, ever inspired by the soul; but the external causes reside in its common form, which corresponds exactly to the influx and operations of objects. Thus this power is constantly there; and does not flow in during the day only, as in the case of the eye. For the softness, hardness, and similar properties of bodies, are perceived correspondently to it [the common form] and its qualities, namely, its yielding, softness, and capability of reacting. According to its vital heat or warmth, is the sensation communicated by every temperature, warm and cold, that strikes us; for besides the affections arising from external sensations, there are also affections from internal causes, which vary our senses, and touch particularly, in a singular manner (n. 558). These then are the causes that create potency, and constantly preserve it. *But in order that an active force conformable to the potency, may be excited, it is necessary that the object, to the operation of which the organ has been formed, or is ultimately instructed, to correspond, should come from without, and imprint an image of itself; and that the organ should react agreeably to the mutation induced by the impression* (n. 552).

humors; the conglobate glands, by the lymphs; the spleen and pancreas, by cruor and serum of their kind; the liver, by sanguigenous chyles; the gall-bladder, by its gall; the members of generation, by touches and agitations, mutual and alternate. By which considerations we are again presented with the conclusion, that if any particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life (n. 567).

CHAPTER II.

THE SENSE OF TASTE.

574. In Part I., which treats of the viscera of the abdomen or the organs of the inferior region, we spoke in the first place of the tongue and its functions, and premised the anatomical observations of Heister, Winslow, Malpighi, Swammerdam, and Boerhaave, respecting the tongue, its nerves, arteries, veins, muscles, glands, conical corpuscules, and papillæ: and therefore here, where we are only treating of the sense of taste, we are bound to preface no more particulars than concern that sense, or sensorium, specifically. Yet on account of the connexion of the papillæ with the muscular fibres, that is to say, on account of the relation of this sense to the action of the organ, the reader will find it expedient to procure a knowledge of the whole fabric of the tongue from the authors in the place alluded to, and other sources.

575. Heister. "The nerves of the tongue are very large; consisting of two branches from the fifth pair which are usually thought to be gustatory, and of two from the ninth pair which are considered motor. . . . The muscular substance of the tongue is surrounded by three involucra, tunics or membranes. The external, which is continuous with the common membrane of the mouth, forms a number of pyramidal and globular pouches or vaginulæ, which are porous, and serve for receiving the nervous papillæ of the third membrane. The middle, or membrana reticularis Malpighii, consists of a beautiful network, which transmits the nervous papillæ through its apertures; this is visible only on the upper part; but is more difficult to detect in man than in brutes. The third, or membrana papillaris nervosa, visible only in the same part of the tongue as the last, contains nervous papillæ of different shapes, but chiefly fungiform, (similar to snail's horns or fungi,) full of little holes, . . . and capable of protrusion and retrac-

tion; also pyramidal papillæ large and small, and sometimes incurvated. Both these kinds of papillæ arise from the internal membrane of the tongue, and from its nerves; they pass through the little foramina in the reticular membrane, and terminate in the vaginulæ of the external membrane. These papillæ are the primary organ of taste." *(Comp. Anat.*, n. 285.)

576. WINSLOW. "The upper surface of the tongue is entirely covered with a thick membrane or tunic of a papillary texture, upon which lies a fine epidermoid membrane, which is likewise continued over the lower surface, but without papillæ. Three sorts of papillæ are distributed over the upper surface of the tongue: capitatæ, semilenticulares, and villosæ. The papillæ of the first kind are the largest, resembling little mushrooms with short stalks. They lie on the base of the tongue in superficial crypts or fossulæ. They resemble small conglomerate glands, seated on a narrow basis, and a little hollowed in the middle of their convex side. They occupy the whole surface of the base of the tongue, and are arranged in such a manner, that the anterior ones form an angle. These are glandular mammillæ or papillæ, or salivary or mucilaginous glands. . . . The papillæ of the second kind, or lenticulares, are small orbicular eminences, only a little convex, the circular border of which is contiguous to the surface of the tongue. When we examine them with the microscope in a fresh tongue, we find their convex sides full of small holes or pores, like the end of the spout of a watering pot. They lie on the middle and anterior parts of the tongue, in greater or lesser numbers, and are sometimes most visible on its edges. . . . They soon lose their consistence after death, so that by rubbing them several times, they may be drawn out in the form of small soft pyramids, and laid down on one side. The papillæ of the third kind, or villosæ, are the smallest and most numerous, and occupy the whole of the upper surface of the tongue, and even the interstices between the other papillæ. They would be more properly named papillæ conicæ, than villosæ, from the figure which they appear to have when examined in clear water through a microscope. They are naturally softish, but they become so flaccid after death, that by handling them they may be made short and thick, whereas they are naturally long and small. *(Exp. Anat., Tr. de la Teste*, n. 506—512.) Besides the membranes of the tongue already described, it is customary to mention another,—the membrana reticularis; which is commonly demonstrated from the boiled tongues of oxen or sheep, and some assert that it exists in the human tongue. *(Ibid.*, n. 529.) We observe four nervous fasciculi or cords, going distinctly to the base of the tongue, and continuing their course to the apex. Two of these are branches of

the inferior maxillary nerves, or of the third branch of the fifth pair from the medulla oblongata. The other two are branches of the ninth pair. . . . The lesser portion or first branch of the eighth pair, sends likewise a nerve to each side of the tongue. The great lingual nerve on each side glides forwards, . . . and is distributed to the muscular fibres all the way to the apex of the tongue; communicating by several filaments with the small lingual nerve or branch of the fifth pair, and with the nerve from the eighth pair. . . . The small lingual nerve on each side separates from the maxillaris inferior, sometimes at, and sometimes above its passage between the two pterygoid muscles. After separating more and more from the trunk, it passes under the lateral part of the tongue, over the sublingual gland. It gives filaments to the nearest parts of the tongue as it passes, and then entering its substance terminates at the apex, having sent a great number of filaments to the papillary membrane. It communicates, as has been said, . . . with the nerve from the eighth pair. *(Ibid.,* n. 533—535.) The lingual nerve of the eighth pair, which is the first branch of this pair, runs first of all on the inside of the digastric muscle of the lower jaw, and gives filaments to the genio-hyoideus, the neighboring muscles of the base of the tongue, and those of the pharynx. Afterwards it gives out ramifications and forms anastomoses, . . . and lastly goes to the lower part of the tongue, where it communicates with the lingual branches of both the fifth and ninth pairs." *(Ibid.,* n. 538.)

577. MALPIGHI. "In the exterior or superior part [of the tongue of the ox], . . . an immense number of bodies, disposed in a kind of series, rise from the surface, and slightly curving, exhibit a uniform inclination and position towards the posterior part of the tongue; so as to resemble a carding comb. . . . In the ox they are cartilaginous, and seem to have a particular resemblance in figure to the teeth of the boar and other similar teeth; and inferiorly they exhibit a concavity, at their roots especially. They are composed of a dense and tough material, which looks like a collection of little twigs. . . . All these cornua are invested by the external membrane of the tongue, so that when this membrane is pulled off, the external covering of the cornua is pulled off with it. . . . The conical and obtuse bodies which supply the place of the cornua at the base of the tongue, are evidently hollow, and their substance becomes so thin and so much dilated, that it not only affords room for the nervous papillæ to enter them from beneath, but is also transparent. . . .

"When this membrane [the membrane in which the cornua are implanted] is . . . pulled off, . . . we observe a kind of glutinous substance, extending over the superior part of the tongue especially, and

of some thickness. . . . It extends in the form of a membrane, or thick rete, and has conspicuous openings corresponding to all the cornua; and innumerable little canals between them, which can be seen only by the microscope: these are of different shapes, and open on the surface of the tongue, whence, if it be torn across, or examined by the microscope up against the light, they become visible; and inasmuch as an accurate view shews, that on the inside this membrane represents a dark-colored rete. . . . I therefore think it ought to be regarded as a cribriform and reticular substance. . . . The glutinous substance extends completely over the upper area of the tongue; at its sides the dark portion is nearly obliterated; but traces of it are visible in the palate and even in the cheeks.

"After examining the glutinous substance, we next come to a nervous and papillary substance, of a yellowish white color; extending in the form of a membrane over the whole of the superior area particularly, and of considerable depth. This substance, on its inner surface, where it is connected to the muscular parts of the tongue, appears smooth and even; with the exception of certain nervous connexions or processes, scattered here and there between the fleshy fibres, and to which it is connected, or rather grows. On the exterior part, however, it is rendered uneven by certain remarkable nervous papillæ which proceed from it, and which are disposed in a very astonishing order. In the ox, the goat, the sheep, and in the human subject, these papillæ may be divided into three kinds, according to their threefold configuration and magnitude. Some are much larger than the rest; these are situated at the sides of the apex particularly, between certain others to be mentioned presently: they are disposed in a square on the superior area of the tongue; about its middle region, where it becomes white, very few are observed: but there are some, and those of considerable size, at the sides of the base. In substance and shape, these resemble the emissile and retractile cornua which are observed in snails; they stand on a long peduncle, which having risen through the mucous substance, ends in a little round head, that is placed in a sort of cavity in the thin exterior membrane. They originate from the nervous and papillary substance; for they are continuous with it, and the same circumstances, and a very similar structure, are observed in both. They have, however, this peculiarity, (which I hear has also been observed by Fracassatus,) that in the base of each there is a nervous twig, to which it is appended, or rather grows. The nervous papillæ of the second kind are more numerous than those just mentioned; corresponding on the inside to the cornua on the outside of the tongue. Proceeding from the common papillary substance, they rise to some height, and

from their summits put forth nervous offsets, which enter the cavities before spoken of, and meet the roots of the cornua; they are surrounded by almost innumerable papillæ from the same origin, and which rise to the same height, but which are conical and more slender, and entering particular cavities in the mucous substance, at length terminate in the direction of the external membrane. About the base of the tongue, instead of the cornua, the nervous papillæ already described project outwards, and changing their form as they approach the base, they successively become more obtuse, rounded, and depressed: and the largest of them are not very much unlike those observed in the cheeks, at the roots of the teeth. It should, however, be noted, that the same papillary substance, and both the coverings under it, are found also in the palate and cheeks, although in a very attenuated form; but with this difference, that larger papillæ stand out in these places in the form of cones, and near them are excretory vessels, implanted in subjacent glands, and among the vessels are scattered a few very minute nervous papillæ. . . . Many nervous twigs proceeding from the trunk terminate in the nervous and papillary substance." *(Exercit. Epistolic. de Linguâ.)*

THE SENSE OF TASTE.

578. *The objects of taste consist of parts of the three kingdoms, to wit, the mineral, the vegetable, and the animal, which parts are comminuted and dissolved in their aqueous and other liquid menstrua, and in the salivas particularly, and on being applied to the little sensoria of the tongue, are perceived as to their qualities; the perception or sensation itself, is called taste.* It is clear that the objects that excite the feeling of taste consist of very minute parts, that come out at last from the solutions of the food, and swimming in fluid menstrua, are applied by them as vehicles to the sensorial papillæ; this being proved by the first origin of those parts from their parent kingdom; by the process of comminution and solution that they undergo; by the nature of the chyle, serum, and blood into which they change; and lastly by those parts that are discharged in the form of urine. *By the origin of those parts from their parent kingdom;* that is to say, in the first instance from the earth, or from its proper kingdom, the mineral; for out of this the vegetable kingdom is generated, brought forth, and maintained; from which at length comes the animal kingdom: thus whatever arrives by order of succession in the animal kingdom, appears to be taken originally from the mineral, but to be transferred into the animal body by the mediation of the vegetable kingdom. *By the process of comminution and solution that they undergo;* for the materials taken by the lips and mouth, are ground between the teeth by the action of the lower jaw, and are still more exquisitely comminuted by the tongue; the buccal parietes and the palate conjointly assisting, and the liquids drank, and those expressed from the succulent food, and above all, the salivas, lending their aid; and this, until the above materials have

been reduced to the parts that float in those liquid menstrua, or vehicles, and are applied for the purposes of taste to the little individual organs of that sensorium (*p*). *By the nature of the chyle, serum, and blood into which they change*, or for the preparing and nourishing of which, they serve: for all the food that is taken by the mouth, ground by the teeth and tongue, and entrusted to the stomach, is for the sake of the blood (*q*); and when the latter, or its serum or chyle, is explored chemically, then the origin and character of the minimally reduced parts themselves that are applied on the very threshold to the papillæ of taste, begin to be manifest. *Lastly, by those parts that are discharged in the form of urine:* for those matters that do not admit of being comminuted, sucked out, and purified so as to become chyle, are rejected as dead, in the form of alvine fæces; and those that are separated as stale, antiquated, and useless, from the serum and the decompounded blood, are excreted by the liquid way that is furnished by the kidneys, the ureters, and the bladder. All these considerations shew very clearly the distinctive character of the parts that are first tasted in the rostrum, or tongue, or that are explored by taste. *By*

(*p*) The palate concurs with the tongue in all the offices of the latter; in sucking, eating, tasting, transmitting salivas, and absorbing juices. (Part I., p. 71, 72, n. 61—63.) The fauces are cases and forms modelled to the tongue. *(Ibid.*, p. 76, 77, n. 66.) When the tongue is about to eat, it conspires in a wonderful manner with the cheek and the palate. *(Ibid.*, p. 78, 79, n. 68.) The salivary humor is so prepared, as to be singly sufficient for all the offices of the tongue; for restoring and renewing its states, for moistening the food received, and which is to be worked about, for dissolving it when ground by the teeth, for sheathing the juices extracted from it, and afterwards for insinuating them into the lacunæ and little canals. *(Ibid.*, p. 41, n. 38; p. 99—102, n. 81, *m*, *n*.)

(*q*) The blood contains everything that is contained in the body. *(Econ. A. K.*, tr. i., n. 2, 3, 5, 59, 61, 115.) All things are for the sake of the blood. *(Ibid.*, n. 4.) There are many kinds of salts in the blood *(Ibid.*, n. 43—45, 91, 92), which are carried to it by the chyle *(Ibid.*, n. 49), and by the pulmonic air. *(Ibid.*, n. 50—52.) The composition of the blood, what. *(Ibid.*, n. 91, 92, 95, 96, 107, 108, 110, 371.)

the objects, in fine, we know the character of the organ, because the two mutually correspond to each other; for the organ represents a common form, whereof the mutations are so many types fashioned exactly to the impressing objects as their ideas [or antetypes].

579. *Speaking generally, all figured parts, both simple and compound, that have angles and planes, fall under this sense.* This is proved by the same arguments as we adduced in proof of the former position; for from whichever of nature's kingdoms the parts are borrowed, if we examine them by the microscope, they all appear diversiformly angular, sharp-pointed, convex, lunated, excavated, plane, ragged, rough, made up of more simple parts, and varied in such infinite ways, that it is impossible to express and designate them either by speech, drawing, or geometry (*r*). Light itself evidences the same thing by variegations of shade; being broken and reflected according to every variety in the composition of parts, which circumstance is represented to our eyes by the various species of colors; wherefore colors themselves are additional signs of the figured character of the parts that are taken from the three kingdoms to become objects of taste (*s*). If this sense were not modified

(*r*) This is abundantly shewn in the treatises of many authors, who have investigated the forms and figures of the parts of the three kingdoms with the microscope; and have demonstrated for instance the nature of the parts of the mineral kingdom, which are simpler than those of the other kingdoms, and for the most part triangular, rectangular, equilateral or isosceles, square, oblong, unequal in their sides or scalene. The forms of the parts of the vegetable kingdom are innumerable; as much so indeed as the genera and species of vegetables, shrubs, juices expressed from them, resins, wines, oils, and spirits. The parts of the animal kingdom are seen reduced to more perfect and in short circular figures and curves of different kinds. That stupendous art, whereby the parts of the mineral kingdom, after having been divided into their elements, or to their unities, are disposed into infinite kinds of forms, is only natural chemistry. Meanwhile, it appears from all [authorities], that these parts are figured, or are possessed of angles and planes.

(*s*) I think it is clear enough, that when light traverses figured corpuscules, it is especially variegated by shadows, but not so when it

by diversity of figures, it would be unable to indicate any distinctions at all to its general sensorium, by corresponding mutations; for the organ represents a common form, whereof the mutations are so many types fashioned exactly to the impressing objects as their ideas [or ante-types] (n. 578). But the shapes and configurations of parts are so numerous, that it seems scarcely possible to reduce them to distinct classes, although possible to reduce them to universal genera and common species. The most simple are trigons, inasmuch as these take the lead of all angular forms; for all bodies with solid angles, in a word, all polygonal bodies, as geometry shews, are ultimately reducible or resolvable into trigons as their constituents, just as all plane figures are ultimately reducible into triangles (*t*).

580. *But which are naturally so far inert and weighty, that when applied to the little sensoria, they can imprint a type of*

passes through minute spherules: and for this reason, color itself may be taken as an argument that the above parts are possessed of angles and planes: for it is an ascertained fact, that nothing produces the various conditions and forms of shadowed light more distinctly and exquisitely, than volatile, urinous, alkaline salts, and sulphurs, as being so many triangular corpuscules, or prisms and excavated quadrangles; and when they are grouped together in an orderly manner, the result is a joint modification, either red, or green, or yellow, and thus a scene is displayed that is not apparent, distinct, and comprehensible, save by the common perception of sight. (*Econ. A. K.*, tr. i., n. 87, 88.)

(*t*) Respecting the figures of inert parts, or respecting the particles of fixed, volatile, essential salts, oils, waters, &c., see our brief disquisition in *Econ. A. K.*, tr. i., n. 69—79. And that all compounds when resolved into their first elements, produce trigons, consisting of four three-sided angles, and of three sides similarly* hollowed in, see *Ibid.*, n. 71, 72.

* Swedenborg had said previously: "Experience shews, that the individual [elements] of sea salt are generated in the waters, or between the rudely-spherical, hardish, and naturally almost inert aqueous particles. Granting this, it follows, that these elements are of the form of the interstices between the particles of water; in short, that they are little cubes, with six sides and eight angles; and that their sides are *hollowed in* so as to fit the convexities of the aqueous particles." (*Econ. A. K.*, tr. i., n. 70.)—(*Tr.*)

themselves, and cause a corresponding mutation. This again is collected from the same arguments; namely, as well from the fact, that the above parts are taken from the three kingdoms, and indeed originally from the mineral kingdom (n. 578);—for the earth itself is a round mass of weighty corpuscules, resting there as in the spacious centre of their universe: their figures also prove their inertia or gravity, in that they have diversiform angles and planes (n. 579);—as from the other fact, that they have to be disengaged from the masses in which they cohere, and to be broken up by menstrua; and again from the circumstance, that they have to be applied to the little sensoria by the assistance of the fluids and salivas; and finally from their manifestly ponderable character. Thus it is clear, that taste and smell are excited by corpuscules endowed with *vis inertiæ,* that stamp a figure of themselves upon the little papillary forms (n. 522). The case is different with sight and hearing, the organs of which are accommodated to the modification of the auras, and therefore do not receive the impulses of inert forces, but the forms of active forces (n. 523).

581. *And moreover are of such a magnitude, that they can act distinctly upon the individual parts of the organ of this sense.* That which stamps must not exceed in dimension that which is to be stamped; if it either exceeds this, or does not come up to it, or is larger or less than it ought to be, no mark is left, and no type moulded. The one must correspond to the other in measure, mode, and degree, so that there may be a ratio between them (*u*). From these considerations it is evident, *that the sense of taste, or that savor, is excited by means of fluids, by particles possessing figure,* vis inertiæ, *and just magnitude.*

(*u*) It is evident from the papillæ themselves, that the conditions of taste are different from those of touch; for the papillæ of taste are not congregated into bundles like those of touch, but are divided and discriminated from each other; in order that each saporiferous or edible part carried to them by means of its liquid, may approach and affect its papillæ individually, and thus distinctly excite the unities of this sense, so that the common affection that is called taste may proceed from many thus excited; for the sensorio-organic form of touch is twofold (n. 565, *ad fin.*) .

582. *The figures or configurations of parts produce all the varieties and differences of this sense; consequently the sense itself, inasmuch as it consists in variety; but not so the forces of the same parts, or the circumstance that they are intrinsically and naturally inert or active, for the forces only excite the life of that sense, or cause taste to exist. But the measures or various dimensions of parts, merely sharpen or blunt this sense, or render it more or less distinct or obscure.* The same law prevails in each of the other senses; for example, in hearing, which has sounds for its objects; for the figures or forms of the glottis, palate, tongue and mouth, produce all the varieties of sound, so far as relates to degrees of altitude, or to differences between acuteness and gravity: but the forces increase or diminish the intensity of each tone, and cause the sound to strike the organs of hearing with force or feebleness; thus either excite or extinguish its life. Quantities, again, make the sound distinct or obscure, shrill or dull. The case is similar in sight; the forms and images that are its objects, according to their varieties, induce varieties coördinate with sight. But the forces of light, according to their degrees, illustrate, exalt, and intensify the same; while shades, as being negations of force, completely obscure and extinguish them. Magnitudes cause these forms to appear distinctly or obscurely, that is, acutely or obtusely. And the same obtains in the other senses. *Thus the figures of parts cause sense to be in potency, for all sense consists in variation of modes. The forces of parts cause sense to be in act, or to exist. But quantities prescribe limits to its spheres; and if it transcends these limits, it becomes obscure, or fails from excessive subtlety.* But to apply this to taste specifically: inasmuch as figures cause this sense to be, or to be possible, it is plain how many differences of it there may be; to wit, as many as ever there are species and varieties of minerals, salts, flowers, grasses, shrubs, roots, fruits, seeds, juices, oils, spirits, tinctures, menstrua, drugs; also as there are varieties of flesh and humors in the subjects of the animal kingdom, both in the simple and in the compound; or as there are shapes intermediate between those bodies that are most pointed, and those that are entirely devoid of angles; or in general terms, between trigons and spheres, the surface of which latter is a kind of infinity, where every angle and di-

versity of planes is obliterated: wherefore if saline acid be assumed as the first boundary of simple taste, the sweetest saccharine flavor will be the last boundary corresponding to this first. But each species of savor has its first and last, consequently innumerable middle terms: for taste comprises not only acidity and saltness, but also bitterness, austereness, acerbity, acrimony, and many other terms with their opposites, answering to all the diversities of composition in nature's kingdoms (*y*). But as regards the nature of forces specifically, impressions are made not only according to the gravity of the object, but at the same time according to the forces acquired by the motion of the fluid vehicle: for the salivas and certain extracts of the food are of such a character, that they envelop inert parts, apply them closely to the papillæ, and by their quick rolling power, make them either impinge tooth and nail upon the points, or gently rub against the plane and concave surfaces (*z*). But the case is different with elastic, soft parts, possessing intrinsic activity, which when applied to papillæ similarly elastic, soft, and active, yield to them, and *vice versâ;* these cause only kisses and salutations, but not touches and impulses. Such appears to be the nature of the intercourse between many of the salivas and the conical papillæ; and also between the finest chyle and the papillæ of the stomach and intestines; for these fluids either affect most blandly, or else enter the little mouths of the pores absolutely without the papilla or vein being con-

(*y*) *Bitterness,* as in emetics, purgatives, rhubarb, wormwood, aloes, colocynth. *Austereness,* as in certain unripe fruits, and even in grapes. *Acerbity,* as in galls and cypress-nuts, &c. *Acrimony,* as in mustard, pepper, pellitory, euphorbium, &c.; besides other differences, also involving something generic; for instance, *unctuous softness,* as exhibited in fats, ointments, glutinous things, and oils and balsams, the degrees of which run from the varieties of tenacity to the greatest extremes of toughness. The varieties of *saltness* are equal in number to the genera of salts, from common salt, or rock salt, down to insipid alkaline salt. *Mawkishness,* as in certain earths and boles, whereof various species produce nausea.

(*z*) Respecting the nature of the saliva, see Part I., p. 99—102, n. 81 (*m, n*). Respecting its varieties and different offices, see *Ibid.,* p. 83, 84, n. 71 (*i, k, l*); p. 85, n. 72 (*n*).

scious of the circumstance; the particles of the food seem to be tempered in the laboratories to so high a degree. Wherefore the differences arising from the nature of forces, make their stated boundaries between the highest life or sense of savor, and its extinction. But with respect to the dimensions of the corpuscules specifically, they sharpen or blunt the sense, or render it distinct or obscure, and prescribe limits. For if there be several things that simultaneously engage and irritate one papilla, indistinct and confused mutations are produced; and if continuous quantities exceed the dimension of one or more papillæ, they also equally obscure the sense; giving rise to indistinct general ideas, and not to particular ideas. On the other hand, if quantities be so very small as only to touch, hit, or sooth some fibre of a papilla, no sensation of this degree or genus results; for an entire papilla is the unity of the sensorium, and hence a change of the entire unity produces the first particular of the sensation (n. 549, 565). The larger quantity falls above the sense, the smaller falls beyond it.

583. *But the larger parts, which do not fall under the sense of taste, or under savor, in the tongue, fall under a sense more akin to touch: and from this mixture [of senses], an additional number of varieties and species of this sense arise, which cannot by any means be discriminated distinctly.* Touch is present distinctly in the organs of the other senses, and governs in a general manner as it were with them as companions (n. 525). And not only in the papillary cutis, but in every fibrous texture whatever, therefore also in the sensorial organs (n. 530). Touch also admonishes the organ of taste of the existence, quality, and quantity of that which is either taken in openly, or glides in furtively, and which that organ is shortly about to explore in a different manner (n. 570). Nevertheless, touch, taste, and smell are different from each other in nature and character; this being proved by the origin, degree, effect and use of each, as well as by the evidence of our own feelings (n. 524). There are three kinds of papillæ, to wit, capitatæ, lenticulares, and conicæ (*a*), all seated upon the upper surface of the tongue;

(*a*) Heister mentions only two kinds of papillæ, for he distinguishes the pyramidal papillæ into greater and lesser (n. 575). Winslow says:

the one receiving the marks of impressions altogether differently from the others, if each be recipient according to its organic form: that is to say, undergoing changes from impressed objects differently, and reacting differently (*b*); applying themselves also severally to different objects, because they severally differ in magnitude; to wit, to particles and minute pieces [of food], which are resolved again and again into lesser pieces, and ultimately into least; which shews that the papillæ are little organs that correspond to every dimension of the divided parts. It is evident that each species enjoys a peculiar sense, from the fibrous texture of each; for fibres creep up into each from the common basis or body (*c*). But what this sense is,—whether it is properly taste in one kind of papillæ, properly touch in another, is an object for investigation: if it be touch, it should not be identified exactly with the touch of the papillary substance of the cutis, since this substance is formed of contiguous, coherent papillæ, and feels under the scales of the epidermis, with which it is covered in. But not so the three kinds of papillæ in the tongue, which are not confasciated but discriminated, and not covered in with scales, but only with a thin membrane, or common cap, which is elastic, and yields when

"Three sorts of papillæ are distributed over the upper surface of the tongue: capitatæ, semilenticulares, and villosæ [or conicæ]" (n. 576). According to Malpighi: "In the ox, the goat, the sheep, and in the human subject, these papillæ may be divided into three kinds, according to their threefold configuration and magnitude" (n. 577). "On the dorsum of the tongue," says Boerhaave, "especially at the apex and edges thereof, under the skin, lie obtuse papillæ, which appear to be of three different kinds; in a tongue that is alive, warm, moist, thrust out, and applied to taste anything, they project from the surface, particularly when the person is hungry." (Part I., p. 30, n. 30.)

(*b*) According to the peculiarities and successive modes of operating stated above, n. 552.

(*c*) "Both these kinds of papillæ," says Heister, [alluding to his division of the papillæ into greater and lesser,] "arise from the internal membrane of the tongue, and from its nerves; they pass through the little foramina in the reticular membrane" (n. 575). The papillæ of the first kind, or fungosæ and capitatæ, "originate," says Malpighi, "from the nervous and papillary substance. . . . They have, however,

the subjacent papilla extends (*d*). Therefore, in order to explore the appointed peculiar sense of the papillæ, it is necessary to examine their forms, both particular and general; for in order to the existence of a sensorium that can apprehend the several varieties of an object with their differences and distinctions, the fibres must be disposed into an organic form: for the fibres are put together and the form conceived with reference to every kind of variety and idea of use (n. 531). Wherefore it would be right and proper, if we would be instructed by the sciences in the secrets of nature, to judge of the sense from the form, and of the form from the sense; for in the organ, as in a mirror, we may contemplate the sense, and see the nature of it; and *vice versâ;* the one being exactly represented in the other (n. 548). Since then we find three kinds of papillæ, each kind with a distinct form, planted upon the tongue, hence we have three kinds of senses, all however related to touch, and which correspond to the parts disengaged from the dry food, or floating freely in the liquids that have been drank; namely, to the larger, the middle-sized, and the least parts: so that no so-

this peculiarity, (which I hear has also been observed by Fracassatus,) that in the base of each there is a nervous twig, to which it is appended, or rather grows. The nervous papillæ of the second kind . . . proceeding from the common papillary substance, . . . from their summits put forth nervous offsets" (n. 577). And with respect to the more slender and conical papillæ, he says: "Many nervous twigs proceeding from the trunk terminate in the nervous and papillary substance." *(Ibid.)*

(*d*) Winslow states that the papillæ act under the cover of a continuous membrane resembling the epidermis, and not under the cover of scales. "The upper surface of the tongue," says he, "is entirely covered with a thick membrane or tunic of a papillary texture, upon which lies a fine epidermoid membrane, which is likewise continued over the lower surface, but without papillæ" (n. 576). And Malpighi says [respecting the conical papillæ], that they "terminate in the direction of the external membrane" (n. 577); and [respecting the fungiform papillæ], that they "end in a little round head, that is placed in a sort of cavity in the thin exterior membrane" *(Ibid.)* And according to Heister, the papillæ "terminate in the vaginulæ of the external membrane" (n. 575).

lutions or divisions escape without being explored by an appropriate sense, and manifesting their external qualities and accidents. This again is the source of infinite varieties; in fact, of varieties thrice multiplied into themselves, or tripled; and which it is the more difficult to display by the sense alone, inasmuch as we have not yet explored the proper powers of each sense, and so many varieties are involved in every one of the senses, that myriads of them produce but one common affection (*e*): and there is again a further source, if these varieties be implicated with another sense equally luxuriant in varieties of its own. Wherefore, not to set sail on a boundless ocean, it is better not to venture far from port, but only to make a short excursion into general, and perhaps only into most general, predicates.

584. *The papillæ of the third class, conicæ, pyramidales, or villosæ, are the principal sensoriola of taste or savor* (*f*). For they are the most numerous of all the papillæ, filling every little hollow of the tongue, and covering its upper surface from the top and both the edges; and moreover they are so minute, that they fill the interstices between the rest of the papillæ (*g*);

(*e*) We may see this clearly by a little attention, while we are eating, or bathing the tongue with sapid liquids: for all the papillæ that beset the surface of the tongue, are saluted by the circumfused liquids, or the ground and extracted food; and not only the conical papillæ, but also the others, as the lenticulares and capitatæ: and nevertheless from these infinite touches, in which there may be innumerable varieties, nothing but one common savor arises: as though we should commix the most diverse essences, distinct in taste, whether essential juices, or wines, or service-berries, into one, and form a common product from them all.

(*f*) The reader may see it explained also in Part I., in the Chapter on the Tongue, that the conical or pyramidal papillæ are the proper sensoriola of taste (p. 49—52, n. 43); and that figured parts are the objects of taste. (*Ibid.*, p. 52, n. 43, *ff.*)

(*g*) "The papillæ of the third kind," says Winslow, "or villosæ, are the smallest and most numerous, and occupy the whole of the upper surface of the tongue, and even the interstices between the other papillæ. They would be more properly named papillæ conicæ, than villosæ, from the figure which they appear to have when examined in

they are extensile, contractile, elastic, susceptible of every variety of state and form (*h*); adapted for scrutinizing the least points of tangible substances; the first-born offspring and growth of their parent fibres (*i*); therefore exquisitely sensitive; most numerous, fine, simple, and modifiable, and most like their parent fibres in nature and genius, on the apex and borders of the organ, at the points which the food first touches, and where it is first received; and as they are smaller than the other papillæ, so also they are more perfect; closely resembling the papillæ of touch that exist in the lips and other prominent or receding parts of the circumference of the body; the only difference lying in the simplicity, origin, place, and perfection of the papillæ of taste, and in their being sundered from each other, and not grouped together in bundles, but each searching its own particle by sense, and all bringing together modes and as it were shares of sensation into one; and conveying the common modification and affection thence resulting, to the sensorium, or to the organic principles of their fibres: hence the difference is, as between parts that act separately, and parts that act simultaneously in a continuous expanse: or as between the lights, colors, or images of one plane, that fall into our sight distinctly and yet simultaneously; and lights, colors, or images that represent themselves confusedly as one thing. The

clear water through a microscope" (n. 576). Respecting the same papillæ, Malpighi says: "They [the nervous papillæ of the second kind] are surrounded by almost innumerable papillæ from the same origin, . . . but which are conical and more slender, and entering particular cavities in the mucous substance, at length terminate in the direction of the external membrane" (n. 577). These latter, being conical, exactly resemble the papillæ of touch, which likewise rise from a broad base: not so the other papillæ, which grow from a narrow and small base, and expand into a broad surface.

(*h*) "They [the papillæ conicæ]," says Winslow, "are naturally softish, but they become so flaccid after death, that by handling them they may be made short and thick, whereas they are naturally long and small" (n. 576). And Boerhaave says: "Laurence Bellini has shewn by careful experiments, that these papillæ are the organ which receives the impressions of taste from sapid objects." (Part I., p. 30, n. 30.)

(*i*) See above, note (*c*).

former create a joint modification of a delicious kind, full of diverse harmonies and pleasant play; the latter, an unpleasant modification, destitute of variety and satisfaction, and chaotic, confused, and obscure. We see from the papillary organ of the cutis, that the papillæ that rise through the foramina of the corpus reticulare, represent the unities of our touch; and that by the mutual apposition of these unities, and their orderly association, an organic form is produced, which is the organ, or as it is commonly called, the sensorium of touch. The scales of the epidermis regulate and temper the sense (n. 549). From which it appears, that touch is the most obtuse and indistinct of all the senses; and more obtuse and indistinct in proportion as a larger number of papillæ is pressed, or affected, at the same time (n. 550). In this respect, taste is discriminated touch, and therefore its papillæ are furnished and covered with an epidermis that is not divided into scales, but continuous, and gathers together the particulars and ratios of touches in harmonious concert. Therefore, *what principally distinguishes taste from touch, is, that the papillæ of taste are discriminated, but the papillæ of touch collected; and thus the former bring out their sense separately, but the latter bring out theirs conjointly.*

585. *But the papillæ lenticulares, as well as the papillæ fungosæ, seem to possess a kind of intermediate or obscure sense of taste.* For they likewise are organic offsets or growths produced from a fibrous stock, yet not fashioned for receiving all varieties, as sensoriola should be; inasmuch as they are at the same time designed for foretasting and sipping the first chyliferous essences, and the salivas themselves. Thus they are comparatively flat, and resemble snails' horns, or fungi; for they stand on a slender stalk or peduncle, and swell out at the top into a little head, so that they are not pyramidal, but almost the reverse. Then again they are perforated with little holes in the middle and round about, to enable them to admit the more refined lymphs, and the innocuous extracts, into the bosom of their cavities, and to propel them onwards through little tubes into the blood. Thus they are inaugurated at the same time into another function besides the sensorial function (*k*), in their

(*k*) The papillæ fungosæ or capitatæ of the tongue are the very organic parts that take the first taste of the nutrient essences of the

performance of which they do not attend, like little sensoria, to single varieties; nor every moment assume fitting changes according to the solicitation of contingencies, and the use that must ever be present. But still we may conclude from their fibrous structure, and from their surfaces being even put forward into contact with advancing objects, that they do enjoy an intermediate or second-rate sense (*l*). Touch exists not only

food, imbibe them with their little mouths, and transmit them through continuous ducts and channels immediately into the blood. The glandulæ semilenticulares represent the same as the larger glandulæ fungosæ, only in a still more perfect manner. Hence these two sets of organs do not belong properly to the sensation of taste, but to the libatory and manducatory offices of the tongue; not excreting saliva, as commonly supposed, but drinking the first extracts and occult essences of the food, or the juices that it yields, and satisfying and renovating the needy blood, and breaking its fast. This is abundantly proved by a multitude of effects. (Part I., p. 44, 45, n. 42.) The papillæ fungosæ, according to Winslow, "resemble small conglomerate glands, seated on a narrow basis, and a little hollowed in the middle of their convex side. . . . These are glandular mammillæ or papillæ, or salivary or mucilaginous glands. . . . The papillæ . . . lenticulares are small orbicular eminences, only a little convex. . . . When we examine them with a microscope in a fresh tongue, we find their convex sides full of small holes or pores, like the end of the spout of a watering-pot" (n. 576).

(*l*) Sensibility is not to be denied to the papillæ fungosæ and lenticulares, simply because the papillæ conicæ are properly sensorial. (Part I., p. 49, 50, n. 43, *aa*.) For they too, according to Heister, are "capable of protrusion and retraction" (n. 575); and according to Malpighi: "In substance and shape, these [papillæ fungosæ] resemble the emissile and retractile cornua which are observed in snails; they stand on a long peduncle, which having risen through the mucous substance, ends in a little round head" (n. 577). But here it will be well to annex a part of the disquisition by the last mentioned illustrious author, respecting the sense of these papillæ. "Whether," says he, "all the three orders of nervous papillæ mentioned above, or only some of them, contribute to the production of taste, . . . is a question. The large size of the papillæ of the first kind; their intimate and firm connexion with, and their continuation from, the nerves, seem to identify them principally with the office of tasting. Yet as they are few in

in the papillary cutis, but in every fibrous texture whatever (n. 530). For it is excited by contiguous objects that strain the connexion of the parts, and especially of the fibres; or influence their position, order, and series, and thus change and invert their states, properties, and functions (n. 529). If any

number, compared with the others, and are not observed in all the parts in which taste is probably exercised, . . . and in other parts are disposed in such an order, that a very considerable space is left between them; and nevertheless, there seems to be a sense of tasting in these little parts [or little spaces],—on these grounds there is some room to doubt whether the passion of taste may not find convenient organs in the other papillæ also. Whether or not they perform other uses, is equally doubtful. Angelus Fortius in the last century taught that the finer particles of the food ascend to the brain through the radicles of the nerves, &c. . . . There is a celebrated observation of Cardanus, in [the case of] Augustus Corbetta, to whom pepper gave the feeling of pain, and not of taste, &c." *(Exercit. Epistolic. de Linguâ,* p. 18, 19; fol. Londini, 1686.) By the principles already laid down, we may see how touch is excited instead of taste, according to the experience of Augustus Corbetta, as handed down from Cardanus, by Malpighi; and indeed according to the proper experience of each individual. For since taste is principally distinguished from touch by the circumstance, that the papillæ of taste are discriminated, but the papillæ of touch collected, and thus the former bring out their sense separately, but the latter bring out their's conjointly (n, 584); it follows, that the papillæ and glands of any one of the three kinds, when affected simultaneously, present the sense of touch, and not of taste: for touch is a common or simultaneous affection, but taste is the manifested idea of particulars, all agreeing in harmonious variety. Hence when many papillæ of the tongue are affected simultaneously,—for instance, by some large object, the idea of touch arises, and not that of taste. This again is clearly perceptible from the pieces of the food, which come under the sense of touch, before they come under that of taste. When pepper is taken and rolled upon the tongue, it evidently produces both senses, for whatever is dissolved into parts by the process of extraction, falls instantly under taste. Wherefore, according to the proposition, touch admonishes the organs of taste and smell, of the existence, quality, and quantity of that which is either taken in openly, or glides in furtively, and which those organs are shortly about to explore in a different manner by their senses (n. 570).

particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life (n. 567). From which it follows, that these parts are excited by their sense, both to undertake and go through their functions; which consist in drinking the first extracts and occult essences of the food, and satisfying the needy blood, and breaking its fast [n. 42]; for parts, and series constructed of parts, are excited by the irritation of touch, both to undertake and go through their functions (n. 573).

586. *The cartilaginous bodies that are found in the tongues of certain animals, elevate this common and compound sense to a very great degree.* These corpuscules are implanted in the same basis and membrane as the other papillæ; they also rise through the foramina of the reticular tunic or mucous substance; they likewise are concealed under the common cloak; are covered in by a kind of fine peridemis, or rather perichondrium, and cover the papillæ in a kind of excavated hollow; and those contiguous to the papillæ transfer the individual concerns of all into the general. Thus making the sensations more evident, they convert them into a species of finer touch (*m*). To say nothing of the other offices that they attend to at the same time. This provision is designed to meet the case of those animals that live on herbaceous food, and have to receive their conditions of life from the external senses, and not like the human race, chiefly from the internal senses (*n*).

587. Touch, or the sense arising from the impulse of bodies

(*m*) The reader will find a complete description given by Malpighi of these little cartilages, n. 577; from which description we may obtain confirmation of our propositions: for sense is greatly exalted where the fibres and membranes are connected to cartilaginous, horny, or osseous parts, as demonstrated above, n. 530.

(*n*) This is also a reason, why the tongues of the more imperfect animals, as fish, and insects, that live almost in sense alone, or in the instinct of a nature produced or excited by the senses, are likewise furnished with cornicles and squamous cartilages of the kind. Such for instance is the case, according to Swammerdam, with the naked or house-snail, the covered snail, and the cuttle-fish; in which latter, "the tongue," says that author, ". . . consists . . . of seven little cartilaginous bones, . . . [and] every one of the seven . . . is provided with above

endowed with gravity or *vis inertiæ*, is so universal, that it prevails everywhere in the body, both in its circumference, and in its innermost recesses; for if any particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life (n. 567). Yet as it is so luxuriant in variety that it is never alike in any two points, but plays most diversely, according to all the organic forms upon which those [gravitating] corpuscules impinge; therefore, in order that this sense, with its so innumerable, not to say infinite, varieties, may fall under more distinct ideas of the understanding, I will divide it into its proper classes, or into genera and species, and present its diversities for contemplation under these.

588. *There are three universal species, or superior genera, of the sense of touch, each of which has its allotted regions and provinces in the living body. The first genus, and the most general, prevails all over the circumference, and is properly called touch:* in other words, it prevails in the boundary intermediate between the ambient world and the corporeal world; or between the great world, and the little world made in its image (n. 484). For which reason this sense, placed in this station, has the province or function of attending to, and occupying itself with, all the mutations that can possibly assail the body from the world without; and of exploring and indicating them, by taking upon itself in each case a corresponding mutation. These mutations are the objects of this sense: for the fibres are put together and the form conceived with reference to every kind of variety and idea of use; as the papillary form with reference to touch (n. 531). Its first use is, to perceive all the changes occurring in the circumambient world, and communicate them to us: and thus to keep both watch and ward; to notice whatever happens, and by means of its organ placed on guard, to protect, at the same time that it institutes communications (n. 568, 569).

589. *The second genus prevails in the innermost parts of the body, beginning from the tongue; namely, in the œsophagus, the stomach, the intestines, and in fine in all the organs of the infe-*

sixty curved, dentiform, cartilaginous papillæ, somewhat resembling the papillæ of the tongue of the ox." (Part I., p. 29, 30, n. 29.)

rior region, or viscera of the abdomen. This sense, on its first threshold, is called taste. It is a most remarkable circumstance, that the hollow viscera in a continuous series, from the first mouth of the lips down to the very end, are covered with the same papillary down, or silky villosity as it is called, as the prolabia themselves, and as the tongue, which is prefixed to those viscera, and sits in the rostrum or pulpit thereof. I am now alluding to the œsophagus, the stomach, and the small and large intestines: and not only is it the case with these viscera, but also with the liver, in its glandular follicles, which a second time digests, filters, and washes the portion of chyle received from the above viscera; lastly, with even those viscera that carry down the liquid excrements, I mean the ureters and the bladder. And corpuscules of the same kind as affect the tongue with touch or taste, above, in the threshold of the viscera, that is to say, in the mouth, also go to affect these succeeding cavities with a similar sense. Again these cavities in like manner direct and apply their little villous sensoria to those corpuscules that have passed down to them; and by their vermicular creeping, as the tongue by its rolling and folding, they suffer no part to pass them, without taking a complete account of it, and exploring it by continued touch. Nay, that they search the little fragments offered to them, with some unknown power of feeling, is evident from various symptoms; for instance, from sudden changes, recoveries of strength, longings, loathings, unnatural appetites; from anxieties, windy gripings, heartburn, nausea, head-aches, fainting, &c., arising from the presence in the stomach of incongruous food; bitter, styptic, emetic, or virulent drugs; and particularly of worms, such as ascarides, tæniæ, &c., that twitch and gnaw the internal coats of the above viscera, and the tender villosity of those coats (*o*). From these

(*o*) These particulars belong properly to this place, and therefore I have transferred them hither *verbatim* from a former paragraph (n. 526); but as they were there corroborated in the notes by the experimental evidence supplied by our authors, I forbear to dwell upon them again, lest I should do my task twice over. Meanwhile, the reader will find the subject more fully canvassed in Part I, on the organs of the inferior region, or the viscera of the abdomen, in my analytic investigations of the several organs.

and many other considerations it is evident, that *this sense has the office of taking cognizance of, and exploring, the whole of what is taken by the mouth for the purpose of serving as nutrition to the body, and principally to the blood* (*p*). All such materials are objects of this sense. But since the papillary forms of these viscera do not depend upon fibres originating in the cerebrum, but upon fibres originating in the cerebellum, hence the touches in them do not reach the consciousness of the general sensorium, that is, of our innermost sensorium (n. 527).

590. *The third genus of this sense likewise prevails in the innermost parts of the body, but beginning from the nares; namely, in the larynx, the trachea, the lungs, and their vesicles; consequently in the organs of the superior region, or thorax. This sense in its first entrance is called smell.* This sense, in the province thus appointed for it, diligently searches out those figured and inert, but nevertheless volatile parts, that are flitting about in the atmospheres of the world, (not like taste, those that are floating in water and other liquids,) and penetrate in abundance into the secret æolian recesses of the lungs (*q*).

591. *These are the superior genera of this sense, which speaking generally, is named touch; but with respect to the middle genus, which is properly called taste, it is divided into as many inferior genera, or less universal species, as there are viscera of the abdomen.* Offices differ from each other proportionably as

(*p*) I think there is no occasion to establish this proposition by further arguments, since I believe it was proved satisfactorily in Part I., where I treated of the viscera of this region, that all these organs are formed entirely for the sake of preparing the blood, and nourishing the body by means of the blood. Thus: the blood is the principle of all things in the body. (Part I., p. 236, n. 179, *b*.) The viscera of the abdomen are entirely for the sake of the chyle, the blood, and the serum. (*Ibid*, p. 267, 268, n. 201, *c*; p. 510—526, n. 326—334.) The offices of those viscera, in general terms, are chylification, sanguification, purification, and again chylification. (*Ibid*., p. 510, *seqq*., n. 326, 327, *seqq*.)

(*q*) Having made up my mind to treat of Smell in the very next Chapter, I think it would be premature and superfluous to illustrate this subject further at present.

objects; viscera or organs, as offices; and sensations, as organs; for one thing determines another, and all things flow in series according to use, which is the first and last line and rule: for the sake of use, sense is placed on guard as an informant and messenger, and keeps watch and ward everywhere. The objects that excite this sense, are not the same in the tongue as in the œsophagus, the stomach, and the other cavities and masses; for with respect to their objects, the tongue rolls and foretastes the comparatively crude and still undigested matters; the œsophagus merely sips hastily the materials carried along it; the stomach exquisitely explores the slowly digested essences expressed by trituration, together with the other fluids and solutions; the intestines are different again in these respects, and reduce the ill-conditioned, but unexhausted food, and search it by a sense analogous to our taste. The case is still otherwise with the other members of this province: for by the objects we know the character of the organ, because the two mutually correspond to each other; for the organ represents a common form, whereof the mutations are so many types fashioned exactly to the impressing objects as their ideas [or ante-types] (n. 578). For the fibres are put together and the form conceived with reference to every kind of variety and idea of use (n. 531). Moreover, the differences between the different species of this sense are very conspicuously represented in the papillæ of each viscus; for in one place we find large, in another comparatively small papillæ; in one place the papillæ are tender and delicate, in another hard; in one place thinly scattered, in another place set more thickly (*r*). In these and all other particulars we see a

(*r*) "The fourth or innermost coat [of the œsophagus]," says Winslow, "resembles that of the intestines, except that instead of villi it has very small and short papillæ." (Part I., p. 91, n. 76.) Respecting the duodenum the same author says: "the entire surface of the valves [valvulæ conniventes] is villous, as well as that of the interstices between them. The villous coat of this intestine is thicker than that of the stomach; but its substance does not so much appear to be villous, as fungous and granular, composed of an immense number of fine papillæ of different figures, in which the microscope dis-

condition and disposition of parts manifestly corresponding to all the most minute details of uses. But the viscera themselves have their bonds and relationships, and form series of affinities according to their functions. Thus the stomach and intestines form the closest affinities with each other: the spleen, the pancreas, and the liver with the gall-bladder, with each other: the cellular coat of the intestines, the mesentery, and the thoracic duct with the conglobate glands, with each other; and so on (*s*). By this we may comprehend something further respecting the natural partition of this sense into specific differences, superior and inferior.

592. *These species are divided again into as many particular differences as there are unities in each viscus. So that there are as many specific differences, as viscera; and as many particular differences, as unities.* This again is concluded, not only from

closes a multitude of depressed points and pores, by which their whole surface is pierced." *(Ibid.,* p. 145, n. 111.) In the jejunum, again he observes, that "the papillæ of the villous coat are . . . more raised and wavy than in the duodenum; and each of them seems to be divided into several others, in a peculiar manner. They have been very accurately delineated by Helvetius." *(Ibid.,* p. 146, 147, n. 112.) In the gall-bladder, "the internal or fourth coat has on the inside a great number of reticular folds, covered with small lacunæ, like perforated papillæ." *(Ibid.,* p. 260, n. 195.) The case is otherwise in the stomach, the liver, the ureters, and the bladder, respecting which see above, n. 526 (*y*).

(*s*) The viscera of the abdomen form one series, which is divided and subdivided into many others; and they all respect the blood. *(Ibid.,* p. 312, n. 227.) A trine is necessary in order to conclude anything; and therefore a triad of viscera presides over every function. *(Ibid.,* p. 315, 316, n. 229.) How the viscera constitute certain series with each other, and how each viscus again constitutes a series in its own parts. *(Ibid.,* p. 316, 317, n. 230.) How there is a series between the stomach and the intestines. *(Ibid.,* p. 156—164. n. 124—126.) How, between the spleen, the pancreas, and the liver with the gall-bladder. *(Ibid.,* p. 317—322, n. 231, and the notes.) Between the cellular tunic of the intestines, the mesentery, the thoracic duct, and the conglobate glands. *(Ibid.,* p. 196—198, n. 149, 150; p. 222, n. 170.) Also between the kidneys, the ureters, and the bladder, &c.

compound forms, but also from the forms of unities or parts (n. 531). For the parts of the same organ are specifically distinguished from their companions by differences and variety, and at the same time are conjoined with them in fitting harmony (n. 536). The tongue itself is a clear instance and exponent of these differences between the sensoriola or papillæ; consequently between the minute particulars of the sense itself; for its parts, papilliform, glandular, cartilaginous, and the rest, are constantly and everywhere various; in its extremes, or apex and borders, they are more slender, thus more capable of passion and reaction, than in the middle, or in the base, where, following the law of use, they decrease in fineness, number, and mutual intercourse (*t*). So likewise in the stomach and intestines (*u*). For nature ever plays her game through continual varieties. Hence it follows, that

593. *From the variety of the particular sensations of one viscus, a common sensation arises; and from the variety of sensations of many viscera, a still more common sensation arises. And from all and each of these sensations conveyed by the fibres to the cerebellum, the soul, by means of this sense, here apperceives specifically the states of chylification, sanguification, and purification;*

(*t*) The papillæ of the first kind are arranged in such a manner, that the anterior ones form an angle. The papillæ of the second kind lie on the middle and anterior parts of the tongue, in greater or lesser numbers, and are sometimes most visible on its edges (n. 576). The larger papillæ, or those of the first kind, according to Malpighi, "are disposed in a square on the superior area of the tongue; about its middle region . . . very few are observed: but there are some, and those of considerable size, at the sides of the base . . . About the base of the tongue, instead of the cornua, the nervous papillæ . . . [the papillæ of the third kind] project outwards, and changing their form, . . . successively become more obtuse, rounded, and depressed" (n. 577). And again he says, speaking of the cartilaginous bodies, "Near the sides of the tongue they become so small, as to be almost obliterated; and at the base their place is supplied by certain membranous bodies, whereof the anterior resemble cones, but the posterior, obtuse papillæ." (Part I., p. 26, n. 28.) Respecting these varieties in the tongue, see *Ibid.*, p. 55, 56, n. 47.

(*u*) See above, note (*r*).

in a word, of nutrition (*x*)*; and according to the perception, disposes those viscera to the conservation of the whole and the parts, which is the effect and use that this sense produces.* Since the papillary forms of these viscera do not depend upon fibres originating in the cerebrum, but upon fibres originating in the cerebellum, hence the touches in them do not reach the perception of our general sensorium, which is laid in the cerebrum (n. 527). According to the sensation and affection there arises a disposition to the preservation of the part or the whole; or a change of state in agreement with the affection; then an effect embodying the use that the sensation produces (n. 552). This sense has the office of taking cognizance of, and exploring, the whole of what is taken by the mouth for the purpose of serving as nutrition to the body, and principally to the blood (n. 589). *But at the first point where the tongue is affixed to the os hyoides, and is succeeded by the pharynx prefixed to the œsophagus, this sense in a manner flies away, and betakes itself to another sensorium, that is laid in the cerebellum* (n. 527).

594. *From taste as existing in the tongue, and the idea thereof perceived in our general sensorium, we may in some measure comprehend how this sense is circumstanced within the viscera.* When we carefully examine the anatomy of the tunics of the viscera, we find, as noticed above, that similar little papilliform cones, analogous to villi, stand out upon the inside of them, as upon the tongue; and these are rubbed against by particles of the edible class, similar to those that rub against the tongue itself: and that the tongue is abundantly furnished with sense, we have good reason to know from taste. But as soon as these particles, which are gravitating figures and inert forces, escape past the tongue, and are swallowed by the gorge of the pharynx,

(*x*) The viscera of the abdomen are entirely for the sake of the blood. (Part I., p. 267, 268, n. 201.) Speaking generally, their offices are chylification, sanguification, and purification; and they form together the following circle and everlasting chain of uses; namely, that chylification must take place; that what is chylified, must undergo sanguification; that what is sanguified, must undergo purification; and that what is purified, must undergo chylification; and so on perpetually. (*Ibid.*, p. 269—274, n. 202; p. 510, 511, *seqq.*, n. 326, 327, *seqq.*)

this sense is as it were drowned in an abyss, or flies away in smoke, and no longer stamps its mark upon our sensorium. Hence we are induced to believe, that the sense has really evaporated into nothing; and this so completely, that thereupon we seem to wish to extirpate it from the family of the senses, and to reject it among empty shades: supposing that what we touch and apprehend by sense is the sole reality. But this judgment proceeds from the ignorance and real darkness in which we are, respecting the principles of our sensations, particularly respecting the soul, and even respecting our rational mind itself. It is surely plain and clear from the common suffrage of all experience, that there are more things that fall beyond and also above our sensitive sphere, than fall within it. Beyond it run all the forces and modifications that mount immediately by the fibres to the cerebellum (*y*): above it, all those that fly up through the simpler fibres, which are the unities of our sensorium: and within it, those only that are formed of myriads of forces and modes gathered together, and that rise to the cerebrum. But before I can loosen this knot, and open up a knowledge of the soul, and of our common and innermost sensorium, I will in the meantime complete this matter, which is the object of our present investigation, by certain positions, which the reader may still regard as doubtful if he pleases. Suppose then that there is a soul, that explores those things that do not reach our general sensorium (n. 565, 566). Suppose that this soul, as being most minute, perceives even proximately

(*y*) It was explained above, n. 527, that all the variations of modes that rise to the cerebellum, are stolen quite away from our common sensation. This is what we mean by falling beyond the sphere of our sensations, because beyond the cerebrum, where our sensorium is laid (n. 528). And we so term it also on this account, that not only the simpler modes, which are so subtle, that they may be said to be lifted above that sphere, or else to be hidden within it, but also the compound modes that are carried up to the cerebellum from our viscera, lie concealed from and escape our common sensation. The fibre of the cerebrum occupies the very ultimate boundaries, or the muscular and sensorial circumference of our kingdom: but the fibre of the cerebellum has for its lot the whole interior field circumscribed by these boundaries, where the viscera of the thorax and abdomen live (n. 527).

the very essences of objects (n. 564). Suppose, therefore, that it has a full sense, internal to itself, of the agreement of those objects with the state of the body (n. 572). Suppose still further that it is the soul's chiefest end and love, to hold in society and connexion with itself, entire and together, all and singular things that are rightly coördinated and subordinated in the system of the body: consequently that all those things that favor that conjunction and love, represent themselves to the soul by a species of delight; and all others, that infringe the connexion and disturb the order, are undelightful to the soul, and it regards them with aversion and dread. *From these positions it follows, that this sense affects the soul altogether differently to the manner in which it affects the principles of our general sensorium: those things which are delightful to us sometimes affecting the soul unpleasantly; and those which are unpleasant to us affecting the soul with delight; for all things taste according to knowledge and affection resulting therefrom.* The senses do not indicate to us the essence, form, and nature, that objects have inwardly, but only that they have outwardly; consequently only their figure or external form (n. 559). From these considerations, I think we in a measure comprehend how this sense is circumstanced within the viscera; and still more clearly when we know, that the soul judges of pleasure from utility, but our sensorium, in the inverse way, or of utility from pleasure.

595. *Moreover in the tongue itself there are few things that fall under our perception or sensation;* or within the sphere of our sensation; which few things consist only of the general mutations existing simultaneously in the whole crowd of papillæ, both those of the first, second, and third kinds; for all these, when excited by touch, exhibit but one simultaneous idea, because one confused harmony, or rather agreeable or disagreeable discordance. The varieties answering to the diversity of touches in the several papillæ, multiplied in each genus of papillæ (n. 583), introduce such infinite things into one sense, that no quantity can measure that sense, and no number comprehend it. And furthermore, not only do fibres from the sensorium of the cerebrum insinuate themselves into the papillæ of this sense, but also fibres sent forth from the cerebellum, the latter of which draw this sense away from our perception, and carry it

quite in another path. There are in fact three pairs of nerves that go to the tongue and construct it, and are dedicated to its three functions. The fibres of these nerves are so connected and complicated, that in each function of the tongue they maintain something common with those fibres to which such function is peculiar and proper* (*z*). Such is the ground of our ignorance respecting the distinct functions of the tongue, or respecting the offices of its papillæ, respecting the organism and seat of taste, the functions of the glands, whether they sip the essences that escape from the solutions of the food, or whether they pour forth saliva, and whether at the same time they exercise a preliminary taste: and respecting other questions, that arise simply from the obscurity of our sense, devoid of which we feel our way like the blind, and guess out uses by anatomical inspections of the viscera. The case would be alto-

(*z*) For there are nerves both from the fifth pair, and from the eighth and ninth pairs, that enter the tongue; some of which, with their fibres, principally construct the muscles, some the glands, and some the papillæ; yet still they seem to be so complicated together, and so mutually intertwined, as everywhere to stand in a social relationship to each other. "We observe four nervous fasciculi or cords," says Winslow, "going distinctly to the base of the tongue, and continuing their course to the apex. Two of these are branches . . . of the third branch of the fifth pair. . . . The other two are branches of the ninth pair. The lesser portion or first branch of the eighth pair, sends likewise a nerve to each side of the tongue. The great lingual nerve . . . is distributed to the muscular fibres all the way to the apex of the tongue; communicating by several filaments with the . . . branch of the fifth pair, and with the nerve from the eighth pair," &c. (n. 576). The eighth pair of nerves, or the par vagum, arises from the medulla cerebelli (n. 527, *c, d)*. The tongue has three common offices, to undergo motion, to take a preliminary sip of the essences of the food, and to explore those essences by sense; and its proper offices are derived from these. (Part I., p. 35—37, n. 34; p. 37, 38, n. 35; p. 42—44, n. 41, &c.)

* The meaning appears to be, that each organ of the tongue, motorial, libatorial, and sensorial, besides having its own function in a particular manner, involves the two other functions also in a general manner.—*(Tr.)*

gether different did not the greatest part of this sensation slip away from us (a).

596. *The essential and innermost [impressions] of this sense report themselves distinctly to the soul alone:* just as in the sense of touch, in which it was observed, that the mutations that exist within each papilla give the real essence and life that there is in this sense (n. 564). Which mutations are most distinctly presented to the soul, which alone gives the power to feel; and this, according to the organic form in which the soul has disposed and combined the fibres and papillæ (n. 565). The essential or innermost [impressions] of sense are those that transcend, or rise above the sphere of our sensorium, or what amounts to the same thing, hide themselves deeply within it: as, for instance, in the tongue, those that conceive and generate the sense as it were from its seed; which sense, after it has developed itself into a large organic body, is then for the first time perceived by the sensoria of the body, and being palpable, is acknowledged to be something. *Thus the tongue, like the other sensorial organs, is governed by two rulers; to wit, by our understanding according to the will, and by our soul.* (n. 565, *ad fin.*)

(a) "No less disagreement is there among anatomists," says Malpighi, "respecting the precise seat of taste. The generality of writers have believed it to be the office of the parenchyma of the tongue; others have thought that it is seated in the nervous offsets; others, in the extended and surrounding membrane; and the last opinion given to the world is, that the tonsils, which are placed at the root of the tongue, should be considered as the principal gustatory organ. I need not notice the lengthy controversies respecting the division of the tongue, . . . and its uses; further than to remark, that amid so great a fluctuation of opinion, I shall regard my labor as not altogether in vain, if I can establish firmly any point, be it ever so small." *(Exercit. Epistolic. de Linguâ*, p. 13; fol. Londini, 1686.)

THE END.

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RESPECTING CERTAIN AUTHORS CITED IN THE

ANIMAL KINGDOM.

THE following notices comprise those authors only from whose works Swedenborg has cited passages, or to whose plates he has made detailed reference. Many of the names in the preceding Index are simply mentioned by him, or else occur in the passages that he quotes from other authors; and therefore it has appeared unnecessary to dwell upon them here. In general, only those particulars are given that connect the authors with the "Animal Kingdom;" none of their works being noticed but those to which Swedenborg refers, nor their discoveries dwelt upon unless they illustrate his doctrines.

These notices are principally drawn from the following works:

Haller's "Bibliotheca Anatomica," 2 vols. 4to., Zurich, 1774—1777.

Eloy's "Dictionnaire Historique de la Médecine ancienne et moderne," 4 vols. 4to., Mons., 1778.

The "Biographie Universelle," 52 vols. 8vo., Paris, 1811—1828.

Chambers' "Biographical Dictionary," 32 vols. 8vo., London, 1812—1817.

Aikin's "General Biography," 10 vols. 4to., London, 1799—1815.

The "Penny Cyclopædia of the Society for the diffusion of Useful Knowledge," 27 vols., London, 1833—1843.

For the most part these notices lay claim to no greater accuracy than is guaranteed by the above sources.

BARTHOLIN or BARTHOLINE, THOMAS, a Danish physician and anatomist, born at Copenhagen in 1616, died at the same place in 1680. I. Thomas Bartholin published the "Institutiones Anatomicæ" of his father, Caspar Bartholin, under the title, "Anatomia ex Caspari Bartholini parentis Institutionibus, omniumque recentiorum et propriis observationibus locupletata;" 8vo., Leyden, 1641; and the work was translated into various languages. It appeared a second time with additions, 8vo., Leyden, 1645. A third time, with further additions, 8vo., Leyden, 1651; 8vo., the Hague, 1655, 1660, 1663, 1666; 8vo., Leyden and

Rotterdam, 1669. This third edition of Bartholin was translated into English, folio, London, 1668. The work appeared a fourth time, with the new anatomical discoveries of Steno, Swammerdam, Regner de Graaf, and Ruysch, 8vo., Leyden, 1673; 8vo., Ibid., 1686; 8vo., Lyons, 1677; 8vo., Ibid., 1684. It was the common text-book in the schools until the publication of Verheyen's Anatomy in 1693. II. T. Bartholin's "Acta Medica et philosophica Hafniensia," a work containing many contributions from his pupils and others, and some papers of his own, was published in 5 volumes, 4to., Copenhagen, 1671—1680.

Bidloo, Godfrey, a Dutch anatomist, born at Amsterdam in 1649, died at Leyden in 1713. He published 105 folio plates, representing the anatomy of different parts of the body, which were admirable as works of art, having been engraved by G. de Lairesse, but deficient in point of accuracy. ("Anatomia Corporis humani centum et quinque tabulis per artificiosissimum G. de Lairesse ad vivum delineatis demonstrata, &c., Amstelodami, 1685, in fol. maximo regali.") This work was republished with some additions by Cowper. (See Cowper.)

Boerhaave, Hermann, the most celebrated physician of his age, born in 1668, at Voorhout, near Leyden, in Holland, died at Leyden in 1737. He was the author of numerous works of high reputation on medicine and the collateral sciences. His "Institutiones Medicæ in usus annuæ exercitationis domesticos digestæ," was published in 8vo., Leyden, 1708, 1713, 1720, 1727, 1734, and 1746. The edition of 1708 was a very small work, but the following editions were gradually enlarged, until that of 1727, after which nothing was added. This work has been reprinted frequently in different countries, and translated into various languages, having been a text-book in the medical schools of Europe for many years. It is doubtful what edition was made use of by Swedenborg. Haller, who was a pupil of Boerhaave, published his lectures under the title, "Prælectiones in Institutiones Rei Medicæ," 7 vols. 8vo., Gottingen, 1739—1744; and the work, together with the "Institutiones," was translated into English, (but without mentioning Haller's name,) as "Dr. Boerhaave's Academical Lectures on the Theory of Physic," 6 vols. 8vo., London, 1742; and ed. 2, 1751. Besides this there are two English translations of Boerhaave's "Institutiones;" one by Dr. Browne; the other, rather a paraphrase than a translation, by Dr. John Crawford, entitled, "Cursus Medicinæ; or a Complete Theory of Physic, &c. Done principally from those learned institutions of the learned H. Boerhaave," &c., 8vo., London, 1724. These versions give no idea of Boerhaave's terse and comprehensive style. His fame is founded upon his "Institutiones Medicæ" and "Aphorismi de cognoscendis et curandis morbis." Perhaps no book of equal size in the literature of medicine involves more thought and learning than the former of these works. The first portion of it contains an eclectic system of physiology, mechanical, chemical, and humoral. Boerhaave contends for the existence of the animal spirits, elaborated in the cortex cerebri, and adduces many rational grounds for his belief. (Inst. Med. n. 274—285.) It is said that Swedenborg attended his instructions, at the same time as Monro, the reputed discoverer of the foramen of Monro; but this is uncertain. It is, however, clear that Swedenborg was a diligent student of Boerhaave's works, and his style in many parts of the "Regnum Animale" cannot fail to remind the reader of the rapid manner and full sentences of Boerhaave: see as examples Swedenborg's descriptions of the spleen, the cuticle, and the cutis. To Boerhaave the world is greatly indebted for the preservation of Swammerdam's posthumous works. (See Swammerdam.) Haller terms him "the common preceptor of Europe at the

beginning of the eighteenth century;" and says of him as a physiologist, that "he was wont to recognize many causes contributing to every function, and not, as sectaries do, to rest in some single cause, to the suppression of all the rest."

Brunn or Brunner, J. Conrad a, a Swiss physician, born at Diessenhofen in 1653, died at Manheim in 1727. His work entitled, "Glandulæ Duodeni, seu Pancreas secundarium detectum, accedit Dissertatio de Glandulâ Pituitariâ," was published in 4to., Frankfort and Heidelberg, 1715. There are two editions anterior to this, one of 1687, the other of 1688, but under the title, "De Glandulis in Duodeno intestino detectis." Brunn, like Swedenborg, holds that the pituitary is a conglobate gland, and the percolator of the lymphs of the brain.

Cheselden, William, an English surgeon and anatomist, born at Somerby in Leicestershire, in 1688, died in 1752. I. "Treatise on the high operation for the Stone," 8vo., London, 1723. II. "The Anatomy of the Humane Body," 8vo., London, 1713, 1722, 1726, 1730, 1741, 1750, 1752, 1778. This is an excellent anatomical treatise.

Cowper, William, an English surgeon and anatomist, died in London in 1710. I. His "Myotomia Reformata, or a new administration of all the muscles of the human body," was published in 8vo., London, 1694; and a second edition, more correct than the first, by Dr. R. Mead, folio, London, 1724. II. "The Anatomy of Human Bodies," folio, Oxford, 1697; folio, London, 1698; edited by C. B. Albinus, fol. max., Leyden, 1737; folio, Utrecht, 1750. This work contains the 105 plates of Bidloo, with certain alterations in his explanatory text, and 40 figures in nine plates proper to Cowper. The latter made no sufficient acknowledgment of his debt to Bidloo, who therefore accused him of plagiarism, before the Royal Society; a charge which he met by a lame defence in a malicious pamphlet called "Eucharistia."

Eustachius, Bartholomæus, a celebrated Italian anatomist, born in the early part of the sixteenth century at San Severino, in the Marquisate of Ancona, died at Rome in 1570, or 1574. I. Eustachius published only a few short treatises, which are nearly all collected in his "Opuscula Anatomica: nempe de renum structurâ, officio et administratione; de organis auditus; ossium examen; de motu capitis; de Venâ quæ ἄζυγος Græcis dicitur, et de aliâ quæ in flexu brachii communem profundam producit; de dentibus." This work was published in 4to., Venice, 1563, 1564; with the notes of Pinus, ibid., 1574; again in 1653; by Boerhaave, 8vo., Leyden, 1707; 8vo., Delft, 1726. It was one of the first works of the kind, founded upon repeated dissections, and upon the comparison of different subjects; and is of authority even in the present day. II. Eustachius devoted many years to a great work, "De Anatomicorum Controversiis," which, however, he never published, and the manuscript is lost: but thirty-nine copper plates, engraved as early as 1552, and intended to illustrate the text of this work, were found at Urbino in 1712, and given to the world two years afterwards by Lancisi, with the aid of Morgagni and other distinguished anatomists. ("Eustachii Tabulæ Anatomicæ, quas e tenebris tandem vindicatas, præfatione notisque illustravit Joannes Maria Lancisi," folio, Rome, 1714.) Several editions of this work have appeared with voluminous commentaries; by Manget, at the end of his "Theatrum Anatomicum," folio, Geneva, 1717; folio, Amsterdam, 1722; folio, Rome, 1728, an excellent edition; by Gaston Petrioli, folio, Rome, 1740; by B. S. Albinus, folio, Leyden, 1744 and 1762. This work contains the thirty-

nine plates which had been discovered, and eight others that were already known. The best editions are those of Albinus. Swedenborg used that of Manget, which is not a good edition. It comprises the forty-seven plates in twenty-one, and in other respects is a reprint of Lancisi's edition. Haller describes Eustachius as a man of keen powers, with a natural aptitude for discovery, and for delicate and difficult anatomical investigations, who embraced in his labors a larger field, and made more discoveries, and corrections of previous errors, than any other anatomist.

Fantoni or Fantonus, Joannes, born at Turin in 1675, died in 1758. I. "Dissertationes Anatomicæ XI.," 8vo., Turin, 1701. II. "Anatomia corporis humani ad usum Theatri Medici accommodata," 4to., ibid., 1711. This edition, which is, in fact, a part of the preceding work, relates to the anatomy of the abdomen and thorax only. III. "Dissertationes Anatomicæ septem priores renovatæ, de Abdomine," 8vo., ibid., 1745.

Glisson, Francis, an English physician, born at Rampisham in Dorsetshire in 1597, died at London in 1677. I. His "Anatomia Hepatis" was published in 8vo., London, 1654; 12mo., Amsterdam, 1659 and 1665; 12mo., the Hague, 1681. The last-named edition is said to be the best. II. His "Tractatus de Ventriculo et Intestinis," was published in 4to., London, 1676; 12mo., Amsterdam, 1677. Both the preceding works are given in Manget's "Bibliotheca Anatomica." Glisson's works were collected and published at Leyden in 3 vols. 12mo., in 1691 and 1711. ("Opera Omnia Medico-Anatomica.") Boerhaave describes Glisson as "the most exact of anatomists." According to Haller, he was the first who investigated the nature of fibre, and who contradistinguished irritability from sensibility; yet his doctrine in this respect must have been unlike the modern one, for with him "irritabilitas supponit perceptionem," and "naturalis perceptio fibris insit." (Tr. de Vent., tr. ii., cap. vii.) Respecting the animal spirits, he says: "Dari spiritus animales haud gravatim concessero. Omnes prope Medici omnesque philosophi uno quasi ore idem testantur." (Ibid., cap. viii.)

Graaf, Regner de, a Dutch physician, born at Schoonhove in 1641, died at Delft in 1673. I. His treatise, "De Succo Pancreatico," or "Disputatio Medica de Naturâ et usu Succi Pancreatici," was published in 12mo., Leyden, 1664; and again with additions, 8vo., 1671 and 1674; and translated into French, 12mo., Paris, 1666. II. "De Virorum organis generationi inservientibus, &c.," 8vo., Leyden and Rotterdam, 1668, 1670, 1672. De Graaf introduced the anatomical syringe and made use of liquid injections. His works were collected after his death. ("Opera Omnia," 8vo., Leyden, 1677; 8vo., 1678; 8vo., Amsterdam, 1705.)

Heister, Laurence, a German anatomist and surgeon, born at Frankfort on the Maine in 1683, died at Helmstadt in 1758. His "Compendium Anatomicum veterum recentiorumque observationes brevissime complectens," was published in 4to., Altorf, 1717; 8vo., Altorf and Nuremberg, 1719, 1727, 1732, 1741, 1761; 8vo., Amsterdam, 1723, 1748; 4to., Freyberg, 1726; 8vo., Venice, 1730: in English, 8vo., London, 1721, 1752. It was translated into nearly all the languages of Europe. (See *Senac.*) Many additions were made to it in the edition of 1732, and again in that of 1741. It is uncertain what edition was made use of by Swedenborg. Heister's work is in the tabular form. Verheyen's Anatomy, which had superseded T. Bartholin's, was in its turn superseded by Heister's, which met with immense and well-merited success, and maintained its ground for a long time in the medical schools of Europe. Heister regarded anatomy as the handmaid of

theology: and he has the following fine passage respecting the ends of anatomy: "Finis anatomes multiplex est: primarius tamen est operum mirabilium Supremi Numinis in corpore humano aliorumque animalium cognitio et admiratio: cum artificiosissimæ fabricæ contemplatio, partium admiranda figura, connexio, communicatio, actio et usus, Creatoris non solum existentiam, sed et immensam et stupendam sapientiam manifestissime, contra atheos, demonstrent, et ad cultum ac venerationem ejus invitent; ideoque finis primarius Anatomiæ gloria Dei esto. Atque hoc sensu Anatomia Philosophica, aut Physica, imo Theologica vocari potest, omnibus veræ sapientiæ ac Theologiæ cultoribus utilissima." ("Comp. Anat.," n. 8.) Heister wrote several special treatises on the application of anatomy to Theology. (De Utilitate Anatomes in theologiâ generatim, 4to., Altorf, 1717: ex ventriculi fabricâ, 4to., 1719: ex fabricâ intestinorum tenuium, 4to., 1720: et ex intestinorum crassorum fabricâ, 4to., 1720: ex musculis et mirabili corporis motu, 4to., Helmstadt, 1721: ex nervis, 4to., 1721: ex partibus generationis, 4to., 1723: ex ossibus et eorum nexibus, 4to., 1727: ex mammis, 4to., 1730.)

LANCISI, JOANNES MARIA, an Italian physician, anatomist, and physiologist, born at Rome in 1654, died in 1721. I. His "Epistola de humorum secretionibus in genere, et præcipue de bilis in hepate separatione cum historiâ hepatis," or, "Epistola de bilis secretione ad Joannem Baptistam Bianchi," was published in 4to., Turin, 1711: 4to., Geneva, 1725; and with his "Opera Omnia," 4to., Geneva, 1718; 2 vols. 4to., 1725; folio, Venice, 1739; 4 vols. 4to., Rome, 1745. II. His "Dissertatio de Venâ sine pari," was published with Morgagni's "Adversaria Anatomica" V. (See *Morgagni*.) III. His work, "De Motu cordis et Aneurysmatibus," commenced in 1700, was published after the author's death, folio, Rome, 1728; 4to., ibid., 1735; 4to., Naples, 1738; folio, Venice, 1739; 4to., Leyden, 1743. IV. Lancisi edited the plates of Eustachius. (See *Eustachius*.) He was a man of philosophical tendencies, and the first portion of his work on the motion of the heart is admirable in this respect. He gives the following good advice to the students of medicine: "Interim vero futurum consulo, ut medicinæ tyrones agnoscant, atque identidem revocent in memoriam, permagni interesse ad naturæ operam (cum spe inveniendi) nunquam accedere, quin prius leges, ac principia, quibus tum natura, tum ars operatur, apud animum suum consuluerint: unum enim, idemque Divinum exemplar tum natura, et ars propriis in actionibus, tum philosophus in rectis cogitationibus semper imitatur." He recommends the study of analogies, for says he: "Pleraque in re medicâ per analogiam inventa sunt." (Op. cit., lib. i., sec. i., cap. iii., prop. xvii.)

LEEUWENHOEK, LEEUWENHOECK, or LEUWENHOECK, ANTONY VON, a celebrated Dutch microscopist, and maker of microscopes, born at Delft in 1632, died in 1723. I. His "Arcana Naturæ detecta" was published in 4to., Delft, 1695; 4to., Leyden, 1722. II. "Continuatio Arcanorum Naturæ detectorum," 4to., Delft, 1697; 4to., Leyden, 1722. III. "Epistolæ Physiologicæ," 4to., Delft, 1719. Many of this author's works consist of letters which were inserted in the "Philosophical Transactions." They were mostly published in Dutch, and afterwards translated into Latin. Leeuwenhoek devoted himself unintermittingly for fifty years to the use of the microscope, apparently without any other end than the accumulation of experimental knowledge; for he neither attempted to found a theory, nor to draw conclusions: nevertheless, he pursued his minute researches with too much singleness, not to have elicited many facts which were of use to others.

MALPIGHI, MARCELLUS, a celebrated Italian anatomist, born near Bologna in 1628, died at Rome in 1694. I. He published his "Epistolæ duæ de Pulmonibus," folio, Bologna, 1661; and the work was reprinted by Bartholin, 8vo., Copenhagen, 1663; 12mo., Leyden, 1672; in Manget's "Bibliotheca Anatomica;" and 12mo., Frankfort, 1678. II. "Tetras Anatomicarum Epistolarum, De Linguâ, de Cerebro, de externo Tactus Organo, De Omento, de Pinguedine et Adiposis Ductibus," 12mo., Bologna, 1661, 1665; 12mo., Amsterdam, 1669. III. "De Viscerum structurâ exercitationes anatomicæ, accedit Dissertatio de Polypo Cordis," 4to., Bologna, 1666; 12mo., Amsterdam, 1669; 12mo., London, 1669; 12mo., Jena, 1677, 1683; 12mo., Frankfort, 1678: in French, 12mo., Paris, 1683; by Sauvalle, 12mo., Montpellier, 1683; 8vo., 1687. These dissertations are five in number. 1. De Hepate. 2. De Cerebri Cortice. 3. De Renibus. 4. De Liene. 5. De Polypo Cordis. IV. "Dissertatio Epistolica de Formatione Pulli in Ovo," 4to., London, 1673; in French, 12mo., Paris, 1686. V. "Dissertatio Epistolica de Bombyce," 4to., London, 1669: in French, 12mo., Paris, 1686. The works written by Malpighi until 1681 were published with the title of "Opera Omnia," 2 tom., folio, London, 1686, 1687; and 2 tom., 4to., Leyden and Amsterdam, 1687. The Dutch edition is the best, and has a valuable index: the London edition is inaccurate. VI. "Epistola de Glandulis Conglobatis," 4to., London, 1689; 4to., Leyden, 1690. VII. Malpighi's "Opera Posthuma" appeared in folio, London, 1697; 2 vols. 4to., Leyden and Amsterdam, 1698, 1700; folio, Venice, 1698. The London edition of the Posthuma is very incorrect; the Dutch edition somewhat better. The whole of Malpighi's works were published by Gavinelli, folio, Venice, 1743. Most of his works have been reprinted in Manget's "Bibliotheca Anatomica." Several of the best of them were addressed to the Royal Society of London, of which Malpighi was an honorary member. He wrote in crabbed and difficult Latin, so that it is sometimes almost impossible to guess his meaning. He was one of the first who made use of the microscope in anatomical investigations, and who endeavored to penetrate the intimate structure of the viscera experimentally; in this he was very successful, and laid the foundation of our present knowledge of visceral anatomy. His works on the viscera are constantly appealed to in the present day, but have never been translated into English. He was a sagacious observer, and by no means destitute of method, and philosophical instinct. In philosophy, Malpighi was a follower of Borelli, who, according to Haller, was the first that applied mathematics to physiology.

MANGETUS or MANGET, JOANNES JACOBUS, a laborious compiler, born at Geneva in 1652, died at the same place in 1742. His "Theatrum Anatomicum cum Eustachii Tabulis Anatomicis," was published in 2 vols., folio, Cologne and Geneva, 1716. This compilation is not in much esteem: nevertheless it will be useful to the student of the "Animal Kingdom," from the number of well-executed plates by the best authors which it contains, and from its embodying nearly all the discoveries of the 17th century. It was severely handled by Morgagni throughout his "Adversaria Anatomica" II.—VI.; and by Heister in the preface to his "Compendium Anatomicum." Le Clerc and Manget published together a large work entitled, "Bibliotheca Anatomica," 2 vols., folio, 1685; 2 vols., folio, Geneva, 1699. An abridgement of it was published in English, 3 vols. 4to., London, 1711. This work is chiefly a thesaurus of the anatomists of the 17th century.

MORGAGNI, JOANNES BAPTISTA, a celebrated Italian anatomist, born at Forli

in Romania in 1682, died in 1771. His "Adversaria Anatomica prima" was published in 4to., Bologna, 1706. It is a small work, but, as Haller says, almost entirely consisting of new discoveries, or of more clear descriptions of parts than had been given previously. Morgagni's account of the "appendices ventriculorum" in the larynx has been overlooked by later anatomists, and the same cavities have been recently brought forward as a new discovery under the name of "sacculi laryngis." Five other collections of "Adversaria" were afterwards published by Morgagni; namely, "Adversaria Anatomica" II., 4to., Padua, 1717: III., 4to., ibid., 1717: IV., 4to., ibid., 1719: V., 4to., ibid., 1719: VI., 4to., ibid., 1719. They were all published together as "Adversaria Anatomica Omnia," 4to., Padua, 1719; 4to., Leyden, 1723, 1740. According to Haller, Morgagni did not describe the parts of the human body as if their form was one and constant; but noting the varieties in different subjects, gathered from a number of accordant instances what might be considered as the usual fabric; and in thus eliciting generalized facts excelled all previous anatomists, perhaps with the exception of Eustachius.

Nuck, Antony, a German by birth, but professor of anatomy at Leyden, born about 1660, died in 1692. His "Adenographia Curiosa, et uteri anatome nova, cum Epistolâ de inventis novis," was published in 8vo., Leyden, 1692 and 1696; with Reverhorst's Treatise, "De Motu bilis Circulari, 8vo., Leyden, 1722, 1723 (see *Reverhorst*); and also printed in Manget's "Bibliotheca Anatomica." The greater part of Nuck's works was published in 3 vols. 12mo., Lyons, 1722. The whole were collected and published as his "Opera Omnia," 2 vols., Leyden, 1733. Nuck skilfully injected the lymphatics with mercury, and made use of the air-pump as an appliance for this purpose.

Peyer, Jean Conrad, born at Schaffhausen in 1653, died in 1712. His "Exercitatio anatomico-medica de glandulis intestinorum, eorumque usu et affectionibus," &c., was published in 8vo., Schaffhausen, 1677; in Manget's "Bibliotheca Anatomica;" also in 8vo., Amsterdam, 1682. Peyer described the glandulæ agminatæ of the small intestines, and the glandulæ solitariæ.

Reverhorst, Maurice van, a Dutch anatomist, and professor at the Hague. His work, "De Motu Bilis Circulari," was published in 4to., Leyden, 1692; 8vo., without date; 8vo., 1696; with Nuck's "Sialographia et Adenographia Curiosa," 8vo., Leyden, 1722, 1723. In this work Reverhorst gives plates of the liver, and maintains that a considerable portion of the bile is reabsorbed by the intestinal vessels.

Ruysch, Frederic, a Dutch anatomist and naturalist, born at the Hague in 1638, died in 1731. His works are numerous, but consist in great part of accounts of the preparations in his museum: they were collected and published at Amsterdam in 1721 ("Opera Omnia Anatomico-medico-chirurgica," 4to.); and a better edition, 5 vols. 4to., Amsterdam, 1737. To this is added a "Historia vitæ et meritorum Frederici Ruysch," by J. F. Schreiber; and an admirable Index by Ysbrand Gysbert Arlebout. Ruysch learnt the use of the syringe from De Graaf, and the art of injecting with wax from Swammerdam, and made good use of these means, but never divulged his processes. His preparations, in making which he was assisted by his daughters, were celebrated all over Europe; Boerhaave studied from them, and made them the ground of his vascular theory. Ruysch was little more than an anatomical artist, but in this respect his patience and neatness were wonderful. His great fault was said to be a want of reading, and of acquaintance with what had been done by others.

He was an author for seventy years, and never flagged in his labors. Although aspiring to no other position than a collector of facts,—and Haller justly says of him that he was "simplex totus et a ratiocinio remotus,"—yet he recognized the importance of a higher branch of enquiry; for he says: "Ego totus in eo sum, et omnes nervos intendo, ut quantum in me est, veram constitutionem perscruter, *exspectans ut alii circa usum idem sint facturi.* Difficile enim mihi jam utrique negotio incumbere." ("Thes. Anat." II.)

Schurig, Martin, a physician living at Dresden about the beginning of the 18th century. His works were published between 1720 and 1744. His "Chylologia Historico-medica, sive chyli humani, seu succi hominis nutritii consideratio physico-medico-forensis," was published in 4to., Dresden, 1725. Swedenborg appears to have made considerable use of this learned compilation, as supplying accounts of certain remarkable diseases and diseased conditions, such as adipsia, asitia, pica, nausea and antipathies, catalepsy, ecstasis, &c.

Senac, Jean Baptiste, a French physician, born in the diocese of Lombez, in Gascony, in 1693, died in 1770. Senac published a translation of Heister's "Compendium Anatomicum," with physiological comments: viz., "L'Anatomie d'Heister, avec des Essais de Physique sur l'Usage des Parties du Corps humain, et sur le Méchanisme de leurs Mouvemens. Enrichie de Nouvelles Figures," &c.; 8vo., Paris, 1724; 8vo., Paris, 1735; 3 vols. 12mo., Paris, 1753. Haller speaks of an English translation, 8vo., 1734. (See "Animal Kingdom," vol. II., p. 304, 305.)

Swammerdam, or Schwammerdam, John, a celebrated Dutch anatomist and entomologist, born at Amsterdam in 1637, died at the same place in 1680. I. His inaugural dissertation, "Tractatus physico-medicus de respiratione usuque pulmonum," was published in 8vo., Leyden, 1667, 1677, 1679; 4to., 1738; and in Manget's "Bibliotheca Anatomica." II. His "Biblia Naturæ, sive Historia Insectorum, in classes certas reducta, &c.," was published in folio, Leyden, 1737, in Dutch and Latin, with a life of the author by Boerhaave, who bought the manuscript of the work, and printed it at his own expense. The Latin version was executed by H. D. Gaubius, respecting whom Boerhaave says: "perhaps it would have been a hard matter, if not impossible, to find another translator equal to the task." The work was translated into English, folio, London, 1758. ("The Book of Nature; or the History of Insects: reduced to distinct classes, &c. Translated from the Dutch and Latin original edition, by Thomas Flloyd. Revised and improved by notes from Reaumur and others, by John Hill, M.D.") Swammerdam introduced the use of wax injections, and invented the now received method of making dry preparations of hollow organs. He was an admirable microscopist, and dissector of minute objects, and employed many peculiar and ingenious instruments and methods in his researches. Notwithstanding his experimental studies, he appears in the "Biblia Naturæ" to have constantly had in view the end of displaying the wisdom and power of God as manifested in the animal creation. In the latter part of his life he became a follower of Madame Bourignon, and an admirer of Jacob Behmen, and ultimately forsook all his physical and anatomical studies, in order to attend to his spiritual concerns.

Verheyen, Philip, a celebrated Belgian anatomist, born at Vesbrouck in Brabant in 1648, died at Louvain in 1710. His "Corporis Humani Anatomia" was first published in 4to., Louvain, 1693; and in 8vo., Leipsic, 1699, 1716.

The author subsequently much improved the work, which afterwards appeared with the title: "Corporis humani Anatomiæ liber primus. Editio secunda ab Authore recognita, novisque observationibus et inventis pluribusque figuris aucta," 4to., Brussels, 1710; and with a second volume, viz.: "Supplementum Anatomicum sive Anatomiæ Corporis Humani liber secundus," 4to., ibid., 1710: it was reprinted in 2 vols. 4to., Brussels, 1726; 2 vols. 4to., Naples, 1717 and 1734; 2 vols. 8vo., Leipsic, 1731: the Supplement alone, 8vo., Amsterdam, 1731. This manual superseded that of T. Bartholin; and met with great success, being the anatomical textbook for a considerable period. It is written in a clear and occasionally elegant style, and was certainly the best work on anatomy that had then appeared. Morgagni and Heister attacked it on the score of inaccuracy and want of information, but without perhaps making due allowances, or sufficiently admitting the usefulness of the book in its own generation. Haller regards the supplement as the most valuable of the author's works. Verheyen's motto, written by himself, is as follows: "Philippus Verheyen medicinæ doctor et professor, partem sui materialem hic in cæmeterio condi voluit, ne templum dehonestaret, aut nocivis halitibus inficeret. Requiescat in pace."

VIEUSSENS, RAYMOND, a French physician and anatomist, born at Rovergue in 1641, died at Montpellier in 1716. His "Neurographia Universalis; hoc est, omnium corporis humani nervorum, simul ac cerebri, medullæque spinalis descriptio anatomica," was published in folio, Lyons, 1685; 8vo., Frankfort and Ulm, 1690, not so good an edition as the former; in Manget's "Bibliotheca Anatomica;" folio, Lyons, 1761; 4to., Tolosa, 1775; 4to., Lyons, 1774. Vieussens' "Neurographia" was incomparably more ample and faithful than anything on the subject that had been done before it. Haller describes Vieussens as a man of unwearied industry, who pursued his researches on the brain and nerves, which had hitherto been studied almost exclusively in the lower animals, in the human subject; and whose contributions to anatomy were most important. The reader of the "Animal Kingdom" will find much vigorous thought in the "Neurographia," particularly on the subject of the animal spirits, respecting which our author has treated at length in several chapters; as, "De naturâ et necessitate spiritus animalis, in quo de succo nervoso disseritur," lib. i., cap. xv.: "De materiâ spiritus animalis, de loco, et verâ productionis illius ratione," ibid., cap. xviii. "De dispensatione spiritus animalis," &c., ibid., cap. xix.: "De differentiis motuum, qui spiritus animalis ope peraguntur, in quo distincti ipsius fontes explicantur," ibid., cap. xx. On the points treated of in these chapters, the views of Swedenborg agree in great part with those of Vieussens.

WEDELIUS, JOANNES ADOLPHUS, a professor at Jena, born at that place in 1675, time and place of death unknown. He was the author of a number of dissertations in the form of theses. His "Propempticon de valvulâ venæ subclaviæ ductui thoracico imposita," was published in 4to., Jena, 1714; and again by Haller in his "Disputationes anatomicæ selectæ," 7 vols. 4to., Gottingen, 1746—1752

WILLIS, THOMAS, an English physician and anatomist, born at Great Bedwin in Wiltshire in 1621, died in London in 1675. I. His "Cerebri Anatome cui accessit nervorum descriptio et usus," was published in 4to., London, 1664; 8vo., 1670; 12mo., Amsterdam, 1664, 1667, 1674, 1676, 1683; and in Manget's "Bibliotheca Anatomica." This was Willis's principal work: and contained a new method of dissecting the brain, and a much more accurate account of its anatomy

than had been given previously: it also contained the germs of those modern views of the physiology of the brain which are adopted by phrenologists. The idea of the brain being a congeries of organs is distinctly recognized. Willis, like Swedenborg, makes the cerebrum the seat of the voluntary movements and intellectual faculties; the cerebellum, of the involuntary movements, as those of the heart. In common with nearly all the great anatomists of former times, Willis held the doctrine of the circulation of the animal spirits. II. His "Pharmaceutice Rationalis, seu diatriba de medicamentorum operatione in corpore humano," Part I., was published in 4to., Oxford, 1673; 12mo., Amsterdam, 1674; 12mo., the Hague, 1675: Part II., 4to., Oxford, 1675; 12mo., the Hague, 1677: both Parts, 8vo., Oxford, 1678 or 1679: in English, folio, 1679. This work contains a good deal of anatomical description. Willis's works were published collectively: viz., "Opera Omnia," folio, London, 1679; 4to., Lyons, 1676; 4to., Geneva, 1680; 4to., Amsterdam, 1682; folio, Venice, 1720: in English, 4to., 1681.

Winslow, Jacques Benigne, a Danish anatomist, born at Odensee in the island of Funen in 1669, died at Paris in 1760. His "Exposition anatomique de la structure du corps humain," was published in 4to., Paris, 1732; 5 vols. 12mo., ibid.; 4 vols. 12mo., Amsterdam, 1743; 4 vols. 8vo., Paris, 1776; in English, by Douglas, 2 vols. 4to., London, 1733, 1734, 1743, 1749; 2 vols. 8vo., Edinburgh, 1743: in Latin, 4 vols. 8vo., Frankfort, 1753; 8vo., Venice, 1758. This treatise, in most of the departments of anatomy, superseded all former manuals. According to Haller, it is the common fountain from which the later, and the French anatomists especially, have gained their anatomy; and it is the model on which the generality of the text books of that science has since been constructed. Winslow changed his religion from Lutheran to Catholic on reading the works of Bossuet, and on this occasion Bossuet gave him the addition of Benigne to his name. Before his time anatomists generally took out of the body the parts they were about to examine, so that the relative situation and mutual connexion of the parts was lost and destroyed; and when the cellular tissue was taken away, the very shape was altered. Winslow has the distinguished merit of being the first who described all things in the body *in situ* and *in nexu*. He used to dissect the organs under water.

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Distinction. In the most perfect organic forms, the fibres are thoroughly discriminated from each other, and most distinct in their action, II., 408, 473. Life ceases with distinction of parts, 409, 474. The great mutual distinctness of the least forms in young subjects, 474. The mind is bright in proportion as it is distinct, ibid. Succession and separation in things are necessary conditions of distinctness, 527. See *Fœtus, Humor, Organic Forms, Tongue, Variety.*

Drinking: see *Tongue.* Two powers of the tongue and palate unite in the act of drinking, 79.

Ductus Cholidochus, described by Winslow, 259.

Ear: see *Larynx.* It is constructed on the principle of modified air, II., 449. See *Touch.*

Eating is natural, and in its rudiments precedes volition, 50. See *Tongue.*

Economy, the, of the animal kingdom, is replete with order, stupendous, divine, 339.

Effects derive everything from their causes, and these, from their principles, 194. See *Cause, Efficients, End, Pancreas, Uses.* What is natural and what voluntary in the body may perhaps be concluded from the nerves, but more surely and plainly from effects, II., 108. All ultimate effects are brought about by mere successive mediations, 319. In order to unfold the skin we must have recourse to effects, these being more strongly and easily visible than tissues as examined by the eye, 407. An effect is the complex and sum of all its antecedents, 529. See *Saliva, Stomach, Viscus.*

Efficient: see *Cause, Effect, Pancreas.* The unanimous conspiring of efficients and effects, 276, 293. Their vast multitude, ibid. The continuously successive progression of efficients and effects, ibid.

Ends are all in all in means and effects, 34. Identity of end conjoins parts, 108. The last things so conspire with the first, that the end of the cause is apparent from the effect, 340. The organic form resembles the end inscribed upon it, 341. The body is a mechanism of effects, which are all represented in the soul as ends, 377. See *Cause, Effect, Soul, Use.* The last effect or use is the first in the cause; or is the end; and thus completes the circle of uses, 379. In the animal kingdom, every end is at the same time a beginning, I., 283; II., 315, 330, 420, 446. We live more perfectly the more we respect ends, and more sublimely, the higher the ends, 344. Ends, like causes, describe progressively an entire revolution and circle, 361. See *Life.* The ultimate end of Providence in human life, is the constitution of a spiritual heaven, a kingdom of God, or a holy society, in which the end of creation is regarded by God, and by which God is regarded as the end of ends, 366.

EPILOGUE, the, is analogous in its function to the peritonæum, 526.

EQUALITY, oneness and sameness, produce neither order nor degrees, 55, 56. Nor any society, II., 363. All proportion, analogy and relation, perish in equality, and all sensation; and even union or unity itself, 477.

EQUATION. The effort of the fluids of the body, and particularly of the blood, to equilibrium, may be called equation; referring both to the quantity and quality of the blood, 274. In the body there is perpetual loss and restitution of equilibrium and rest, and consequently change of equation, ibid, and 275. The bronchial artery tends to produce an equation of the cardiac and pulmonic blood, both with respect to quantity and quality, II., 206.

EQUILIBRIUM: see *Action*, *Equation*.

ERRORS. One source of errors is, that we judge of the things that act within us, from those that pass without us, 173. Another source is, hasty generalization from a few facts of our own discovery, 267.

EUSTACHIAN TUBE, the use of, 44; II., 47.

EXPANSION AND CONTRACTION. Nothing can be done in any part without expansion and contraction: they are the vital principles of all operations, 286. The alternate reciprocation and reciprocal alternation of expansion and contraction produce apparent rest, in which no motion is discernible; for the general contraction of the mass, and the synchronous expansion of the glands, give the appearance of absolute tranquillity, 325. The office of each organ determines its conditions of expansion and contraction, 340. Inmost and outmost causes simultaneously concur to the expansion of the fibres, ibid. A wonderful correspondence between expansion and contraction prevails throughout the system, 341. All bodies that expand and contract alternately have the marks of their motion imprinted on their surfaces, which marks are generally occupied by the blood-vessels, 401. Necessity for expansion and contraction in the whole and all parts of the body, and of the universe, II., 139, 460. The expansion and constriction of the cortical glands of the brain, 158. When the blood-vessels are expanded, the spirit-vessels or fibres are compressed, and *vice versâ*. See *Animation*, *Atmospheres*, *Bladder*, *Kidneys*, *Liver*, *Lungs*, *Mesentery*, *Respiration*, *Spleen*, *Succenturiate Kidneys*.

EXPERIENCE is plentiful enough at the present day to serve analysis for the discovery of truth, 9, 15. Experimental knowledge, unless so made use of, is likely to perish, 9. Care must be taken not to wander far from experience, 18. The confirmation of experience by reason, and of reason by experience, II., 116. The various meanings of the word experience, 347. Experience supplies the objects of rational analyses, ibid. Particular experience is not sufficient for the discovery of truth; general experience is required, 349. Experience cannot arrive at truths, without the aid of the sciences, 350.

EXPIRATION: see *Respiration*.

EYE. It is constructed on the principle of modified ether, II., 449.

FAITH. Those who can comprehend spiritual things by faith, need not read the author's books, 14.

FAT, the, described by Heister, 364. By Malpighi, 368. Comparative anatomy of, from Swammerdam, 369. It consists of the exuberant portion of the bodily part of the blood, 373. The blood demands back this deposit, and therewith satisfies its own hunger, and that of the stomach and other viscera, 389. The circulation of the fat is an appendage to the circulation of the blood, ibid. It increases in purity by degrees, ibid. The pellicle of a globule of fat is a miniature omentum, ibid. Its ap-

parent tenacity is owing to its membranes; in itself it is like the thinnest milk, ibid. See *Omentum*.

FIBRE, each, brings with it the nature of its parent, 51, 206; II., 409, 416, 454. The quality of the animus determines that of the fibre, because of the spirit thereof, I., 52, 339. The fibres of the body return in a circle to the brain, 156, II., 409. The fibres are a continued brain, I., 157. They are the essential powers and vital forces of the body, 200. The fibre, in its least forms, as the papillæ, &c., accomplishes nimbly and distinctly, what in generals, as the tongue, &c., it accomplishes sluggishly and obtusely, 207, 222. Longing, loathing, and other states, may be predicated of the fibres, as of the animus of the cerebrum, ibid. See *Mesentery*, *Nutrition*. Nervous fibre acts like muscular fibre, only more perfectly, 216. The simplest fibres are so many determinations of the final ideas of the soul, 242, 339, 488. The simple fibre exclusively is what forms and acts in the kingdom of the soul, 242, 339. The nervous fibres generate the vessels by circumvolution, 243; II., 412. The simplest fibre is the essential form from which all other forms are derived, I., 339. The nervous fibre, what, 489. The corporeal fibre, 490. Every action of the cerebrum and cerebellum is determined through the fibres, and the fibres are determined into act by their principles, II., 158. Wherever any fibre produces a new corpuscule, there it lays aside its former nature, and derives a new nature from its new body, 409. The fibre of the soul and the fibre of the body, ibid. The corporeal fibre, why so called, 410. It constructs the inmost or nervous coat of the arteries, ibid., and 413. It arises in the skin, and terminates in the cortical substances of the brain, 426. The interstices of the nervous fibres are permeable, as well as the fibres themselves, 432. The cortical glands are the principles of the nervous fibres, 461. The varieties of fibres, and the confusion that arises by calling them all by one substantive name, 486. Both the outermost and innermost things are the extremes of the fibres, 551. See *Glands*.

FLUIDS. It is a law that they permeate their canals from a greater to a lesser diameter, whenever they are going to an outlet, 46. They always tend from unquiet to more quiet stations, 47, 386; II., 111, 255, 286, 326, 3[illegible]7. The fluids of the body described by Heister, I., 234. Intrusion of the fluids is never permitted; leave to enter must be given, 239, 348. The summoning of fluid to the fibres according to their need, by a kind of attractive force, II., 81. Wherever there are cavities containing organic parts, there must be some humor, vapor, or unguent, to anoint their peripheries, radii and axes, that is to say, their joints and articulations, 268. See *Humor*.

FŒTUS. The quiescence of the mind, and of many of the organs of the body, during the fœtal state, 398. All things at this time proceed according to the tenor of nature's ends, 400. And the supreme power of the kingdom devolves upon a few organs, ibid., 512. See *Succenturiate Kidneys*, *Thymus Gland*. No particular action separate from the general action can be produced in the fœtus, and why, II., 153. The life of the soul in the embryonic body is an order of forces and operations proceeding *a priori ad posteriora*, but the life of the body is an order proceeding *a posteriori ad priora*, 154, 262, 332. The conditions of the fœtal state, 263. The relative perfection of fœtal life, 264. What was active before birth, became passive and at the same time reactive after birth, 333. The life after birth is the inverse in order and forces of the life before birth, ibid. The means and accompaniments of this inversion, 334. In embryonic life the nervous fibre was the proximate cause of

the heart's action; but after birth, the venous blood, 335. The perfect distinctness of all the structures in the embryo, 440. See *Brain*, *Influx*, *Soul*.

FORCE. Everything is modelled to the forces acting upon it, II., 450. See *Action*, *Lungs*, *Potency*.

FORM. Every particle has its own form and figure, 52. The least forms are the antetypes of the larger, 53. Whenever an action is intended, a corresponding motion is induced, and a form corresponding to the motion generated; thus the form of substances coincides with the form of the active forces; and of the motion producing the action, 124. Forms ascend from lowest to highest, in order and by degrees, 126. The degrees of forms are the angular, circular, spiral, vortical, celestial, and spiritual, ibid. The large, compound, and visible forms in the body, exist and subsist from smaller, simpler, and invisible forms, which act like the larger, but more perfectly and universally, 129. Whatever is manifested in compound and ultimate, arises from simple and primal forms, 130. The higher forms assume relations like those of the great sphere of nature, 134. The simple circle is not the most perfect of forms, and why, II., 314. Our innermost forms are nourished by terrestrial, our outermost by celestial, food, 446. See *Angles*, *Circle*, *Spiral*.

FORMS, DOCTRINE OF, 10, 11, 126. Nature's miracles in the animal body cannot be explored without a doctrine of forms, 198; II., 314. See *Forms*.

FORTIUS, ANGELUS, taught that the finer parts of the food ascend to the brain through the radicles of the nerves, 40.

FUTURE LIFE, the, II., 265.

GALL-BLADDER, the, described by Heister, 255. By Winslow, 259. It is the ultimate asylum of the unclean and obsolete blood, 297. Whatever impurities cannot be defecated in the liver, are sent away into the gall-bladder, 298. It derives its bile, not from the liver, but from the recrementitious blood of the gemellæ cysticæ, 299. Comparison between the gall-bladder and the large intestines, 300. It is a blood-intestine and gall-colon; and also resembles the urinary bladder; being the excretory vessel of the impure blood, as the urinary bladder, of the impure serum, 301. It invites to it the impure blood, and by what means, ibid. Chemical examination throws no light upon the origin of the gall, 297, 305. See *Liver*.

GENERAL, or COMMON. Nature for the most part produces a general on the model of particulars, 48. From generals we may expatiate into particulars, 74. Every general derives its nature from parts, 194. Necessity for general principles, 235, See *Universal*. A general is what contains and distinguishes a universe, its integers and singulars, 492; and II., 390. There are as many general limitations and boundings, as essential parts, or determinations of essentials, I., 492. A general is more universal in proportion as it is less general, 493. See *Membrane* and *Peritonæum*. In proportion as any part is loose from and unconfined by its general, its importance in the society of the body is diminished, 501. The general bonds are relaxed by degrees as life advances, 505. Wherever there is a particular, there is a corresponding general, II., 19, 115. Singular states are in no way changed by the superinduction of general states, 58. What is proper to one thing must also be common to all, 107, 120, 253, 260. The general life is but the sum and complex of individual lives, 192. The laws of influx relating to the common bonds or general membranes, 234. See *Diaphragm*. Particular states constitute the general state, 319. The parts always construct their general, and bring it forth from their own body, 390. In every unanimous society everything must refer itself to some general,

402. What is common grows out of its parts, and not *vice versâ*, 414. See *Heart*. The form of the general is perfected when the form of the part or unity is perfected. 527. See *Nature*.

GEOMETRY: see *Philosophy*. The function of geometry in anatomical science, II., 350.

GLANDS, the, described by Nuck, 224. By Malpighi, 227. By Boerhaave, 230. List of them from Nuck, 233. The conglobate glands regulate the quantity and quality of the lymph, 239. The conglomerate glands are so many models of laboratories, preparing infinite species of humors, ibid. They are in a continual series, ibid. The uses of which they are the causes, are general, specific, and particular, 240. A general idea of their operations, 241. All their conditions are accommodated thereto, ibid. Every gland in the animal kingdom enjoys a plenary communion of its goods and fluids, ibid. See *Mesentery*. The soul disposes all the processes of the glands by the simplest fibres, 242. The fibres composing the conglomerate glands are fourfold in origin, nature, use, and determination, 243. The conglomerate and conglobate glands are mutually antagonistic in their functions; the former destroying the blood, the latter restoring it, 245, 246. All the glands, and the elements of each, have their differences and similarities, ibid. A small gland, if harshly provoked, pours forth as much saliva as a large gland that is treated with mildness, II., 280. Necessity for regulative glands to preside over the excretion of the sweat, 417. The glands lend themselves to all circumstances, and supply whatever is desired, 439. See *Pancreas*, *Pituitary Gland*, *Thymus Gland*.

GOODNESS. The faculty of apprehending the goodness of forms is innate in both the external and internal senses, 1; II., 154, 345. See *Affections*.

GRAVITY: see *Microcosm*. The parts received into the body are exempted from the ordinary laws of gravity, 80; II., 285. Exemplified in the œsophagus, I., 99. In the stomach, 134. In the intestines, 172, 474. And specifically in the jejunum and ileum, 177.

GYRE: see *Spiral*.

HAIR. The hair that appears on the chin at puberty results from the afflux thither of the pituitary and oily lymph of the sheath of the spinal marrow, II., 77.

HEART, the, is produced, and excited to motion, by the small veins, 156. Sanguification is primarily performed in the heart, 213. The heart is a chemical vessel for preparing liquids to enter into the composition of the blood, 214. Its motions are principally kept up by the afflux of blood from the brains and medullæ; but not by the blood of the body, 215. The heart and lungs supply all the members of the body with blood, 337. The heart's office consists in gathering the blood, and transmitting it to every corner of the body, but not in assigning to the viscera the quantity or quality that their offices require, 348. See *Invitation*, *Lungs*. No part demands a freer sphere of activity than the heart, II., 234. Terms of the covenant between the heart and lungs, 235. After birth the heart is raised into diastole by the influx and impulse of the venous blood; its systole being the result of the reaction of its nervous fibres, ibid. Before birth the heart acquired its power of action immediately from the fibres of the cerebellum. Thus it was actuated by internal causes before birth, by external causes after birth, 238, 239. It unlocks the lungs by means of the pulmonary artery, 340. The heart grows out of its arteries and veins, and not *vice versâ*, 414. It is the common centre of the blood-vessels, but is not a collection of a number of centres, like other parts, 485. It is the inverse of other spheres of the body, and how, 491.

HEAT, the degrees of, in the body, 133.

HUMOR. The recrementitious humors always perform some use before they are thrown out, 183. The use of one humor is a means to the use of another, 239. The humors, and the glands that produce them, are correlatives with respect to use, 240. The purer animal juices aspire not only to the prolongation, but to the perpetuation of life, ibid. There is no possible humor to which the blood cannot give genesis, origin, and existence, 242. All the humors institute a continual circuit, after the image of the circulation of the blood, 293, 379, 380. Every humor that nature produces is of so perfect and consummate a character as to be a universal menstruum, 326. See *Member*. All humors constantly follow the parietes of parts, and descend along their plane surfaces; and never escape from the middle of an aperture, unless their quantity be superabundant, II., 37, 275. See *Fluid*. In order that all things may act distinctly, they must be kept separate by an interfluent and circumfluous humor, 269.

HUNGER and thirst are a general desire, arising from the sum of particular desires in all the veins, 85. The singulars and individual elements of the body are what really hunger and thirst, 207, 236.

IDEAS: see *Life*. There are no innate ideas, 2; II., 345. The higher ideas are generated by a continual formation and as it were multiplication of the lower ideas, 343, 351. This process supposes the influx of a spiritual power, ibid. Ideas in themselves are material; but when disposed in analytic order, they are no longer to be reckoned material, but rational, 344, 351. When the ideas of imagination are disposed in a rational series, there arises an intimate sight which constitutes thought, 348.

IMAGINATION is referable to the first internal sense which comes next to ocular vision, II., 95. It cannot reduce the materials in the memory to any order but that which affects the external senses and the inferior mind of the body, 354. It is the activity of the memory, ibid. In respect of sensation, it is nearly at one with ocular sight, 442. It is distinct from both sight and thought, ibid. It exists in brutes devoid of reason, but thought is properly human, ibid.

INCITATION. All parts of the body are excited by a propulsive, active, and living force, which may be called incitation, 274, 294. See *Attraction* and *Invitation*. The general cause of incitation or propulsion is the unanimous effort of the spirits to equilibrium, 275. Incitation in the gall-bladder, 301. The office of each organ determines its incitation and invitation, 340. Incitation is produced by contraction, ibid.

INDUCTION. We may pass with unfailing induction from continents to contents, and *vice versâ*, 185, 219.

INFIDELITY. Its intellectual accompaniments and moral consequences, 14, 15. The author indites his work for those who believe nothing but what they can see; thus to open up a new way of approach to, and acknowledgment of, spiritual things, 15.

INFLUX. After birth all things flow inversely, or from without to within, II., 335, 336. See *Fœtus*.

INFUNDIBULUM, the, represents a preëminent lymphatic, 251.

INSPIRATION: see *Respiration*.

INTELLECT, the human, how generated, II., 346.

INTELLIGENCE. There are three causes that lead to intelligence; experience is the first or ministering cause; the sciences are the second or mediate cause; the faculty of thinking distinctly is the third or efficient cause, II., 347. These three

causes will not conduct to intelligence of real truths unless we extinguish the impure fires of the body, and our own delusive lights, 357.

INTERCOSTAL VESSELS. The blood does not enter them synchronously with the cardiac, but synchronously with the pulmonic movements, 217; II., 246. They come off at right angles from the aorta, 246.

INTERCOSTAL NERVE, the great, arises from the cerebellum, II., 455, and *passim*.

INTESTINES, the, described by Heister, 140. By Winslow, 144. Comparative anatomy of, from Leeuwenhoek, 150. From Swammerdam, 151. Curious particulars of, and remarkable ingesta found in, from Schurig, 153. Authors to be consulted respecting, 154. The intestines are a new, continued, or consecutive stomach, 157. They are analogous to the stomach in their structures, 158. The spires in the concave surface of the stomach are developed into equal solids in the intestines, 159, 160. Their motion and fluxion are spiral, 160, 194. The operations of the alimentary canal are successive, like the articulations, 160. The intestines receive from the stomach nothing but its refuse, 162. They treat the food successively with more vehement motion, grosser heat, longer delay, and a more acrid menstruum, ibid. Each articulation effects and produces something particular for itself, something general for what comes after it, and something most general for all in the series, 163. Each has its own spring of saliva, 164, 181. The intestines perform movements synchronous with those of the lungs, ibid., 515, 520. The movements run from node to node, to and fro, 165. The small intestines wreathe forwards to the valvula coli; the large, backwards to the same point, ibid. They meet at the valve during diastole, but mutually recede from it during systole, 166. The cœcum is their field of expansion, 166. The simple expansion and contraction of their muscular coat produces their movements, 167. Their dilatation involves their extension; their contraction, their retraction, 168. The intestinal gyre respects the fimbriated border of the mesentery as its central circle, and the receptaculum chyli as the centre again of this circle, 169. See *Gravity*, *Mesentery*, *Spiral*. The intestines first throw their contents from their axis, or continued centre, to their concave parietes; and so into their cellular coat; where another force transfers them to the receptaculum chyli, 171. The duodenum inaugurates the intestines into their spiral form and motion, 174. It digests the exhausted and undigested contents of the stomach, and imbibes their first products, ibid. None of the vapor taken up by the arteries of the intestines rises immediately to the cortical substances of the brain, ibid. The glands and papillæ of the intestines absorb fluids, and do not excrete mucus, 175, 196. The intestines do not give, but receive, ibid. Rationale of the operation of purgatives, ibid. The glands and papillæ are the principles of the intestines, 176. The duodenum is capable of an inverse movement, 177. The action of the jejunum, ibid. It evacuates its contents more rapidly than the others, 179. Office of its valvulæ conniventes, ibid. The ileum imbibes none but the less pure chyle, ibid. The cœcum and valvula coli, 180. The appendix cœci vermiformis is the tongue of the balance of the intestinal motion; and pours a fluid into the large intestines, 181. This fluid is proximately obtained from the cellular coat of the intestines; remotely from the cellular coats of the peritonæum and abdominal viscera, 182. The harsh and violent action of the colon, 184. It retains and macerates the food, ibid. The rectum, 185.

INVITATION. All parts of the body are excited by an attractive physical force, corresponding to incitation, which may be called invitation, 274, 294. See *Liver*. The general cause of invitation is the unanimous effort of the fluids of the body,

and particularly of the blood, to equilibrium, ibid. See *Equation*. Invitation of the blood by the gall-bladder, 301. See *Incitation*. Invitation is a kind of attraction, 340. It is brought about by the particular fabric, situation, connexion, modus operandi, and activity of the viscera, 348. See *Attraction*. By virtue of a corresponding invitation and incitation, there is an equation and perpetual circle of all things, and each has its conditions from the community, 360. Embryos suck out the maternal blood through the umbilical vessels; so that the blood is not poured in by the womb without invitation, 408. The air does not rush into the nares unbidden, but is attracted and invited, II., 12. Likewise into the lungs, ibid. No humor ever crosses without invitation into the region of another humor, 260. Not a drop of fluid can flow into the bed of an organ, without the organ inviting it, and determining both the quantity and quality to be supplied, 279. The heart invites the liquor pericardii into the pericardium, ibid. See *Aorta*, *Spleen*.

JAWS, the, described by Heister, 60. Their muscles, 62.

KIDNEYS, the, and the Ureters: described by Heister, 415. By Winslow, 416. By Malpighi, 420. Authors to be consulted respecting, 425. The kidneys are most busily actuated by alternate expansions and contractions, in the whole and in every part, 431. Which are synchronous with the movements of the respiration, 432. The sinuosity of the kidneys is their central region of motion, from which their expansion and contraction begins, into which it returns, and where it terminates, 432. The cerebellum by means of the fibres keeps up their interior motion; the lungs, by means of the peritonæum and diaphragm, their exterior motion, 434. When we know their motion and structure, we can understand their modus operandi, 436. They expunge the stale serum from the arterial blood, and how, 436. The vessels prolonged from the foramina of the blood-vessels of the kidneys, are the first and simplest urinary ducts, 441. The mode in which the urine is excreted and eminged, ibid. The primitive ureters, the middle ureters, and the ultimate ureters, what, 444. The kidneys act upon the serum by violent detrusion, ibid. The tubuli uriniferi are wider above than below, the inverted pyramidal form reigning throughout the urinary series, 446. From the outcast serum, throughout its passage, the veins recover and absorb the finer elements of the blood, 447. The lymphatics redeem its spirituous and essential parts, 449. The suprarenal glands also rescue their portion, 451. The spiritual meaning of "Searching the reins," 431. The kidneys draw off the sluggish and noxious phlegm from the peritonæum, and perhaps a portion of the effete fat, 452. The results effected by them are brought about with infinite variety, according to the states induced by internal, intermediate, or external causes, 454. The varieties in the urine have corresponding to them as proximate causes the same number of changes of state in the body of the kidneys, 455. See *Blood*, *Serum*, *Spiral*.

LACTEALS, the, described by Heister, 187. By Winslow, 190. Authors to be consulted respecting, 191.

LARYNX, the: see *Tongue*. The larynx modifies sounds, 77. Described by Heister, II., 39. By Winslow, 41. Observations on, by Morgagni, 44. Authors to be consulted respecting, 45. The larynx and the ear are correlated as active and passive, and communicate with each other by two ways, 46. Unlike the other organs of the senses, their construction comes within the sphere of sight, 48. All the mysteries of acoustics, music, and harmony, are inscribed on them by nature, ibid. The larynx undertakes and performs the first department of offices in respiration, modulation, and speech, 50. It must have acquired the faculty of opening the glottis into all measures, figures and forms whatever, that can be described by

the geometric compasses, or summed up by the analytic calculus; namely, from the line or fissure, through all possible intermediate curves, both simple, and compounded and mixed in infinite ways, to the complete circle, 52. It must be able to diminish and enlarge these diversiform apertures of the glottis, that is to say, the diameters of the above-mentioned figures, within stated limits, and by reason of the varied dimension, to dilate the field, and multiply the details of the modifications, 57. It must have the power of disposing and conforming the cavity of its tube comprehended by the cartilages, to the whole nature of sound, to the relative size of the aperture of the glottis, and to the correspondent condition of the palate, the tongue, the lips, and the mouth, 62. At the very moment when singing or speaking are intended, the membranes must be put in readiness to receive the sonorous tremblings, and instantly prepared for the proximate series of varieties, 63. The uses of the ventricles of the larynx, ibid., and 68, 70, 73. The laryngeal tube, with all the apparatus below and above it, from the lungs to the aperture of the mouth, must suffer itself to be extended or contracted, suitably to every heightening or lowering of the sound, 68. There is a correspondence between the apertures of the mouth, palate, and glottis, in speech particularly, 70. The larynx must have acquired the power of beginning the sonorous modification at any point whatever, and of determining it whithersoever and in whatsoever quantity it pleases, either through the labial orifice, or through the nares; also of stopping it suddenly in midway, suspending it, and thus breaking it articulately, introducing pauses, taking it up again, continuing and limiting it, according to the articulations and breathing times in speech, 70, 71, 72, 73, 75. In order that the power of performing these offices may subsist in perpetual integrity in its organic parts and membranes, the larynx must renovate them in such manner and measure as use demands, with an unfailing spring of the most suitable humor, 77. The larynx subserves the pharynx in the office of eating, 82. By the disposition of the epiglottis, ibid. By securing the glottis, 83. By reducing the glottis to a mere fissure, and unlocking the sphincter of the pharynx, 84.

LEASTS: see *Atmosphere*, *Fibre*, *Form*, *Liver*, *Lungs*, *Motion*, *Organ*, *Suction*. The stomach consists of lesser and least stomachs, exercising more perfect and universal offices than the large stomach itself, 131. The universe is only the sum of infinite similar leasts, 173. When the vessels are in their leasts, they perform their play with the most perfect distinctness, 283. The least glands of the body are the principles of all operations; and also the ends; and therefore resemble centres, 286. The lungs derive their nature from their centres, or leasts, II., 195. The least vessels in the lungs govern the larger, 197, Everything in the visible world has its determinate maximum and minimum, and proceeds from its maximum to its minimum, and *vice versâ*, 469. The viscera educe from their leasts their power of operating, 475. The greatest is represented in the least, and *vice versâ*, 476. The least fibres that engender each papilla of the skin are what give it essence and potency as a compound, 548.

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364. The ultimate end, 366. There are three common fountains of life, the brain, the lungs, and the heart, 429.

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PERITONÆUM, the, described by Heister, 481. By Winslow, 482. By Verheyen, 484. It produces itself in order into the viscera of the abdomen and their parts, and parts of parts, 494. The members of the abdomen are bound and guarded by the peritonæum and the diaphragm, closely and thoroughly in proportion to their dignity of office and usefulness in the kingdom, 495. In proportion as any of them are slightly confined by the peritonæum, they are more apt to rush into preternatural motions, and more difficult to recall to the standard of nature, 500. The peritonæum reduces the preternatural motions of the viscera to the constant natural motions, ibid. It is the common external bond of the viscera of the abdomen, and the common internal bond of the muscles, cartilages, and bones thereof, 502. The peritonæum and the stomach respect each other mutually as the circumference and axis of a wheel, ibid. It is a general centre of motion to its viscera, ibid. It is the proximately remote general bond between its members and those of the thorax: and the more remote general bond between its members and those of the head, ibid. It sustains the motions of all these as a centre of motion, 503. When the peritonæum begins to be slackened, all the operations of the viscera are performed imperfectly, 503. See *General*. The fluid that permeates the peritonæum comes from the abdominal viscera, 506. It circulates through the whole of the cellular tissue, 507. It never escapes from the cells into the cavity of the abdomen, unless the membranous partitions be ruptured by over distention, ibid. The peritonæum absorbs the fatty vapor with which the cavity of the abdomen abounds, 508. It conveys this serosity to the kidneys, and in the fœtus to the renal capsules, ibid. The peritonæum performs movements synchronous with those of the lungs, II., 154. See *Pleura*.

PERSPIRATION: see *Glands*, *Skin*, *Variety*.

Pharynx, the, described by Heister, 86. By Winslow, 89. Authors to be consulted respecting, 92. It is the receiving vessel of the palate, and the head of the œsophagus, 94. It is both active and passive, ibid. Its sphere of action begins from its linea alba, 95. Its actions follow, and reciprocate with, those of the larynx and trachea, 97. It and the œsophagus receive their blood from many sources, because in their actions they conspire with many parts, 96. It attracts various excretions, from the mouth, the brain, the nose, &c., 97. The pharynx and larynx are married partners, 105. See *Larynx*.

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Pituitary Gland, the, pours new spirit into the blood of the lateral sinuses, 213. It is the conglobate gland of the cerebrum, 251.

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Pleura, the, described by Heister, II., 212. By Winslow, 214. If we pursue its circumflexions, we are conducted at last either to the innermost parts of the lungs, or to the innermost parts of the heart, ibid. They perform a spiral gyre, 223. The circle of the pleura is a transcendent circle, 224. It is the common and proper integument, limit, and bond of the cavity of the thorax, 226. It connects the outermost constituents of the thorax to the innermost, and causes external forces and actions to flow in unimpaired to the vesicles of the lungs, ibid., and 229. The thoracic actions flow in by way of the pleura to the lungs, but not *vice versâ*, 227. The pleura not only infuses the actions of the muscular chest into the lungs, but effuses the forces of this activity into the viscera of the abdomen, both by the external way of the peritonæum, and the internal way of the nerves, arteries, and veins, 230. It transfers the active efforts of the thorax and lungs to the heart, its arteries and veins, 233. It penetrates to the pulmonary vesicles, and with the pericardium enables the heart and lungs to settle their differences, and make a covenant by means of the blood, 235. It conveys the actions of the spinal marrow to the dorsal and intercostal nerves, and thereby to the respiratory muscles, 242. It causes the systaltic movements of the spinal marrow to coincide with the respiratory movements of the lungs, 243. It conveys the actions of the respiratory muscles and lungs to the spinal marrow; and leads round the influx and reflux of causes and effects in an everlasting spiral, 244. It controls not only the spirit of the fibres, but also the blood, dispensing it according to the state of the respiration in conjunction with the bodily actions, 246. The impletion of the pleura with blood, necessary to its functions, 248. The impletion of its cellular tissue with the fluid expressed from its little arteries, necessary to its elasticity, and adaptability to the motions of the chest and lungs, and to its offices as a purificatory and colatory of the blood, 252. The distribution and elimination of its blood and humors, 253. The communication of its humor to the peritonæum, 260. Analogy between it and the peritonæum, ibid. See *Peritonæum*, *Succenturiate Kidneys*, *Thymus Gland*. The cavity is permeable for humor into the pleura and lungs, or inwards, but not outwards, 282.

Pores: see *Skin*.

Posterior: see *Prior*.

Potency. What potency alone can do in any subject, II., 236. One member never imparts to another anything more than potency; for it never deprives the other

of the liberty of acting thus or thus, in one way or another, 237. Nothing results from potency alone; there must be an active force ruling by its motion in order that an action may be produced, 439, 559. The potency of corporeal life requires to be excited by sensation, before it can act and live in the shape of force, 559. See *Action, Force, Lungs.*

PRIOR AND POSTERIOR things are in series and degrees above or below each other, 33. There is no successive progression from prior to posterior things, 276. The progression from prior to posterior is identical with the progression from the soul to the body; the progression from posterior to prior is identical with the progression from the body to the soul, II., 332. The prior and interior sphere is relatively perfect and universal, ibid. See *Nature.*

PROGRESSION. In the skin there is a progression from the greatest softness to the least, and from activity towards inertia, II., 403. See *Efficient, Prior, Series, Spiral, Use.*

PULMONARY ARTERIES AND VEINS: see *Lungs.*

RATIONAL ANATOMY, limits of, 96.

RATIONAL MIND: see *Idea, Thought.* Its operations, 34. It produces nothing by its will but what it has imbibed by way of the senses, II., 338. Its operations may not unfitly be compared with those of algebra, 353. Every rational object has its own soul, 354. The rational mind is in its very nature philosophical, and the fountain of philosophy, 356. It is the uniting medium between the worldly and the heavenly, the corporeal and the spiritual, 364. It constitutes our proper humanity, ibid. It is divided into two powers, a passive and an active, ibid.

REACTION: see *Action, Active, Diaphragm.*

RECEPTACLE. The vena portæ is a receptacle of the blood, 278. The omentum is a receptacle, 380. The trachea and bronchia are receptacles of the air, II., 502. The veins, and specifically the pulmonary vessels, are so many receptacles of the blood, 509. The stomach performs the office of a receptacle, 512. The right auricle of the heart is a receptacle, 515. There are numbers of receptacles in the medullary portion of the cerebrum, 518. The memory is a receptacle of sensations, 521.

RECEPTACULUM CHYLI. It resides in the centre of the body, 202. Its tranquillity and security are necessary to the well-being of the body, 204. Described by Heister, 210. It exercises a propulsive force upon the chyle, 216.

REGENERATION. The functions of the body are an image of the processes in man's regeneration, 451.

RELATION. The perfect mutual relation of all things in the tongue, 53. There is a perpetual relation of parts to their generals, 54. Relations and determinations arise from spheres of circumgyration, 194.

REPRESENTATION, doctrine of, 10, 11. External things represent what internal things contain, 84. Rational sight is represented in ocular sight, and rational light and heat in natural light and heat, II., 359. The life in the last sphere represents the life in the first, II., 461. See *Leasts, Soul.*

RESPIRATION is the essential outermost life of the body, 107. See *Brains, Lungs.* All the functions peculiar to the body commence and cease with the respiration, 399. The muscles of respiration described by Heister, II., 123. Respiration opens the scene of bodily life, and in a certain image represents the higher life, 140. Inspiration is brought about by the force of the incumbent air, assisted by the contraction of the respiratory muscles, 141, 262. Expiration is brought about

by a general contractile effort on the part of the internal constituents of the lungs, assisted by the return of the ribs, and the natural compression of the thorax, 145. In ordinary respiration, inspiration alone belongs to the will, and expiration to nature, 148, 264, 337. In extraordinary respiration, the will sometimes governs expiration, 149, 166. Respiration calls forth the intimate lives of the determinations into actions, or into their ultimate lives, 152. See *Sound* and *Speech*. Respiration is threefold, natural, voluntary, and mixed, 208. Irregularities of the respirations, 209. The different qualities of the respiration are so many general diagnostic marks of the ailments and diseases of the body and animal mind, 210. The respiratory field, 248. The means by which respiration was prevented during uterine life, 262, 331. Every part of the body respires, 460. See *Action*, *Animation*, *Atmospheres*.

SALIVA, the, is adapted to all the offices of the tongue, 41. The tongue is the principal agent in drawing the saliva from the glands, 81. The excretion of saliva is the office of the instrumental cause, not of the principal, 83. The saliva is a menstruum and vehicle, ibid. It is different in every animal, ibid. The oral saliva increases in density from the anterior to the posterior part of the mouth; and why, ibid. The saliva varies continually, according to the affections of the tongue, the brain, and the mind, 84. Whatever takes place in the mind, takes place in the innermost of the blood, and of the saliva, 84. The saliva defecates the blood for the brain and sensoria, 85. The qualities of the saliva are best shewn by its effects, 99. The saliva is in a successive series throughout the alimentary canal, 164, 239. See *Stomach*. The bile is a saliva, ibid., 277. See *Bile*. The last species of saliva distils from the vermiform appendage, ibid. The salivas perform their particular, general, and most general uses, ibid. When the saliva has ceased to be of use to its own member, it is derived into the cavity of the next, 164. Each intestine has its own spring of saliva, 164, 181. Why the saliva is affected in rabies, 208. The chyle is introduced into the blood by means of the saliva, 274. See *Intestines*, *Pancreas*.

SALIVARY GLANDS, the, described by Heister, 63. By Winslow, 66. Comparative anatomy of, from Swammerdam, 69. Authors to be consulted respecting, ibid.

SANGUIFICATION. Chylification and inauguration of the chyle jointly constitute sanguification, 270. It is the work of no one viscus, but of many combined, ibid. Where performed, 512. See *Heart*.

SCIENCES, the, should be applied to use, 15. The empirical sciences supply materials and instruments, the theoretical, laws and rules, II., 349. All the sciences derive their elements from visible nature and the world, ibid. The sciences concentrate ideas, and submit them to terms, and hence give a clear representation of compound ideas, 351. The necessary subdivision and subordination of the sciences, ibid. The infinity of each science, and each part of each, ibid. There is a connexion of all the sciences, and a concentration into one, the universal of all, 352. All the sciences are so many signs of the deceptions and fallacies of our senses, 541. See *Experience*, *Thought*.

SECRETION: see *Serum*. The secretions and excretions are either profitable or unprofitable, and consist of either obsolete or superfluous materials, 271.

SENSE makes instantaneous common cause with motion, II., 20. See *Action*. The five senses are opened at birth when the inversion of life takes place, and convey the forms of the world inwards to the soul, 335. Each sense submits its

gifts to a kind of vision analogous to ocular vision, and carries them into the memory, 348. The experience of no one man's senses is sufficient for the exploration of causes, but the world's general experience is required, for we must be instructed by all things of one thing, if we are to know that one thing thoroughly, ibid. Sensation exists essentially nowhere but in the soul, 462. Certain sensations go first into the memory; certain others go immediately towards the innermost sphere; the latter are analogous to the hepatic and bronchial arteries, 521. Each sensation is a compound of simpler sensations, 547. See *Taste*, *Touch*.

SENSORIUM. In all the sensorial organs, there must constantly be involved, or continually be influent, a power from above or within, and at the same time from below or without, in order that the organ may be in a state for receiving, and applying to itself, that which is offered and represented, II., 559.

SERIES, doctrine of, 10, 11, 316. Every series comprehends an idea of its universe, 37. Everything is a series, and in a series, 53, 317. Digestion is performed in a series, 173. Every series has its maximum and minimum, 276. The passage by a continuous series from compounds to their simples, is called successive progression, 276. From a continual series of differences a compound results that is thoroughly adapted to nature's end, 313. No series can be complete or effective without involving at least a trine, 315. Illustrated in the offices of the abdominal viscera; and in geometry, arithmetic, physics, rationals, and logic, ibid. See *Abdomen*, *Saliva*. There are both successive and simultaneous series, but the latter always arise from the former, 316; II., 85. One thing generates and sustains another in a continual series, 361. See *Unities*.

SERUM: see *Blood*, *Chyle*, *Kidneys*. The chyle, when initiated into the blood, is called serum, 270, 372. The purification of the serum takes place by secretion, 270; II., 288. The different kinds of serum are distributed and treated differently, I., 271. The sera admit of being divided into three general classes, 372, 511. In the fœtal state serum serves instead of chyle, 405, 408, 409, 452; II., 292. The impure serum can only flow in straight lines, and hence is eliminated in the circumflexed vessels of the kidneys, I., 437. See *Succenturiate Kidneys*, *Thymus Gland*. The animal spirit has its serum as well as the blood, II., 431. As these sera are perfectly distinct, so their excretions are not confounded, ibid.

SIMPLES, the, of the blood, what, 236. The blood contains simples of several degrees, ibid. and 270. The more exactly simples are distinguished from each other, the more fitly they are combined, and the more ordinately they are related to their generals, the more perfect is the state of the member, 53; II., 18. There is a perpetual derivation, composition, and convolution of simples, illustrated, 412. See *Blood*, *Leasts*, *Organic Forms*, *Unities*.

SKIN: see *Touch*. The skin described by Heister, II., 372. By Winslow, 374. The pores of, described by Leeuwenhoek, 377. Excretions of, described by Boerhaave, 379. Comparative anatomy of, from Swammerdam, 380. The CUTICLE or EPIDERMIS described by the Author, 386. It collects the particular utilities and functions of all the tunics and strata that lie under it, represents them in itself in a general manner, and completes them; for by those tunics, and on their account, its formation and character are such as we see, 388, 389. It maintains the connexions of the parts spread under it; sustains their changes of state; and impels them to perform their offices aright, 391, 392. Like a coat of mail, constructed of wonderful scales, folds, and joints, it protects and defends the sensitive, soft, and agile tunics that it covers in, against injury from the surrounding air, against

its heat, cold, perturbations, and various conditions not in agreement with the state of the body; and moreover against the rough and stinging particles of its vapors, and of different fluids: and it takes upon itself in the first instance the changes to which these will give rise in the body, tempers them, and tends to break their force, 392—394. It institutes the proximate communications between the circumambient world, and the corporeal world that it encloses; that is to say, it admits from the air and ether comparatively pure, simple elements, which are in harmony with the natural state, and sends them down, as new aliment, into passages that lead to the blood. On the other hand, it sends out obsolete volumes of effluvia, and sweats consisting of useless lymph, brine, and rancid fat, and disperses them into the contiguous air, 394—396. It puts together the primal singular modes of sensation of the fibrillæ and papillæ, into a kind of common mode that is termed the sense of touch; which it regulates, sharpens, and blunts, so as exactly to produce the varieties that nature requires of that sense in the different parts of the body, 397. The CORPUS RETICULARE MALPIGHII described, ibid. It serves as a basis and support to the cuticle: also as a link and instrument of union between the cuticle and the papillary substance, the glands, the vessels, the fat, and in fine, all the subjacent parts: thus as a mediating organ, and as an organ for transferring the modes, actions, feelings and changes of the above parts, to the scales of the epidermis; and from these scales, on the other hand, to those parts, 398—402. It sustains, strengthens, and balances the subjacent parts of the cutis, 402. It gathers together scattered parts, bridges them over, gives them distinctness, reduces them to form: thus it causes everything to refer itself to a general; to proceed in successive series; to flow backwards and forwards in a certain gyre; and to conspire and tend incessantly to equilibrium and rest, 402—404. See *Progression*. The CUTIS described, 404. Its first general use is, to serve as a new source of fibres, and as an end and beginning to the vessels, 405. For there are pores, ducts, and little canals, of a threefold kind, origin, nature, and function, arising from the fibres, and from the same number of organic substances belonging to the cutis, 407. See *Effects*. The pores of the first kind have their origin from the first composition of the cutaneous fibres: their nature is, when drawn back from their apertures, to represent new fibres, which are to be named corporeal fibres: their function is, to suck in the purer elements of food from the air and ether, and to carry them to their ends, and expend them upon the uses of life, 408—410. The pores of the second kind, more properly termed ducts, have their origin from the pores of the first kind, so convoluted as to form a vessel; consequently from the papillæ, to the commissures or interstices of which, they run continuously: their nature is, to be the first and last ends, thus the beginnings, of the arteries: their function is, to expire the thin but worthless effluvia of the blood, 411—414. The ducts of the third kind, rather to be called little canals, have their origin from the subcutaneous glands: their nature is, to be the beginnings of the veins: their function is twofold; on the one hand to throw out of doors, away from the cutis, the vapors and sweats received from the arteries; on the other hand, to suck in the same, and insinuate them into the new formed veins, 416, 417. These three kinds of vessels do not end, excepting where the innermost coat of the arteries, and the outermost coat of the veins, place their boundaries; namely, their boundaries, but of a middle kind, in the chambers of the heart, where all the vessels come together; their ulterior boundaries, in the innermost sphere or vesicles of the lungs; but their last boundaries, where the fibres place their first, in the cor-

tical glands of the brain; hence the indissoluble conjunction and connexion of the last sphere with the first by means of the heart, 420, 422. From this it appears, that the fibres springing up in the brain, again commence anew in the ultimate limit of the body, that is to say, in the cutis, and return in a gyre to their principles; and thence run forth again in company with the parent fibres into their field of uses; so that their circle is an everlasting circle, or spire, in which the idea of continuity, perpetuity, or infinity, is represented, 423.—The second general use of the cutis is, to serve as the foster-mother of the spirits, and the nurse of the blood; and furthermore, as the instrument for throwing out useless matters from both, ibid. For the pores of the first kind, simply bibulous and feeding, immediately convey the elemental food that they sip from the ethereal and celestial auras, through their corporeal, thus venous, fibres, in part to the cortical glands of the brain, which are the prime laboratories of the spirits; in part to the pulmonic cells, which are the little refectories of the blood, and the preparatories that change it from venous to arterial; in part to the left chamber of the heart, the starting place from which the arterial blood comes forth: use and want regulating and dispensing the quantity and quality of this aliment, 424—430. But the pores of the second kind, which we have termed ducts, simply expiratory, put to flight and exterminate the injurious and recrementitious matters that infest the purer blood and the spirit, that irritate the interstices of the fibres and of the nervous fascicles, and that beset the lesser cutaneous parts, 430. The ducts of the third kind, more properly called little canals, in nature and office both excretory and adductory, thus hermaphrodite, purge the arterial blood, the subjacent fat, the muscles, and the integuments of the viscera, that is to say, the peritonæum and the pleura, of their grosser impurities, when the outlet through the other doors provided by nature is not available. At stated times also they seek out and suck in the purer lymphs, or even the thicker vapors, from the air itself; and pour them into the continuous veins, 435—439. And this, unintermittingly, with a kind of systolic and diastolic action synchronous with the pulsific movements of the heart and arteries, which seizes all the cutaneous parts, the little arteries, the papillæ, and the glands, and rouses them to their functions, 439. But with infinite variety, according to all changes of state arising from sensation and affection, outermost, innermost, and intermediate, 440. By an attentive review of the above positions, a knowledge of many of nature's secrets is brought to the light of our understanding, although still in only an obscure manner; for instance, we understand in this way, the derivation, production, and generation, in living bodies, of the inferior and ultimate universal essence from the superior and supreme, 446.

SLEEP. The soul operates to restore the body, particularly during sleep, when the will is at rest, 139; II., 102. The cerebrum collapses during sleep, but opens out during the waking state, 164. The states of sleep and wakefulness compared, 165.

SMELL: see *Nose*. The modes and radii of this sensation mount both by way of the fibres, and of the two meninges, and meet in the cortical substance, II., 17. See *Taste, Touch*.

SOUL: see *Body*. A knowledge of the soul is the end proposed in the "Animal Kingdom," 10. The soul is in the sphere of truths, ibid. It is in vain to seek for the soul anywhere but in her own kingdom, the body, 11. She is represented in the body as in a mirror, 11, 12, 13, 34. It is impossible to leap immediately from the body to the soul; and hence the passage between the two must be effected by means of certain doctrines, 11. All things of the body contain the soul, because they re-

present its series of ends, ibid. As we approach the soul we recede from the body, 39, 52; II., 355. All parts and forms have both a soul and a body, I., 108, 214. The soul's single object while it lives in the body is, to preserve all the powers of the body in their primitive integrity, or to make them subsist as they at first existed, 339; II., 591. The form of the ideas that constitute the nature of the soul, is exactly represented in the organism of the body, I., 341. See *Circle*. Whatever we predicate of nature, we mean to predicate of the soul, 397. It is the architect of the body, 398; II., 141. What share the senses and the soul have respectively in the formation of the intellect, ibid. The soul was the only principle of all motions during embryonic life, 332. It regards only ends and uses, 344. The body cannot unite itself to the soul, but the soul unites itself to the body, 365. At death the soul betakes itself completely to its own higher sphere, 386. It perceives all mutations in the body that are imperceptible to the general sensorium, 549. It is the only essence by which we live, and is absolutely distinct from the intellectual mind, 550. It judges of pleasure by utility; but the senses, of utility by pleasure, 591. See *Touch*.

SOUND, the quantity and quality of, II., 53, 57, 75. In the animal kingdom, the principle of sound is twofold, 72. The universal essences of sound, what, 77. The sonorous tract, 117. The series of causes producing vocal sound, 169.

SPEECH. How speech, at first voluntary, becomes in a manner natural, II, 109. In singing and speech the will performs the part of expiration, 169. Before we are prepared to speak or sing, the air is determined into the most superficial vesicles of the lungs, ibid.

SPHERE. Relations and determinations arise from spheres of circumgyration, 194. There are three spheres in the living body, a sphere of effects, a sphere of causes, and a sphere of principles, II, 370. The soul administers the supreme sphere, and governs the states of principles; the spirit, the inferior sphere, and governs the states of causes; and the blood or body, the lowest sphere, and governs the states of effects, 441. There is perpetual battle and collision of these spheres with each other, 444. The sphere of the body, or the lowest sphere, subsists on terrestrial aliments; the supreme sphere, on ethereal and celestial food; the middle sphere, on both, 445. See *Viscera*.

SPIRITS: see *Animal Spirits*.

SPIRAL: see *Intestines*, *Stomach*, *Use*. The spiral form occurs in the intestines or ultimates of the body; in the brains, or principles; and throughout, in the intermediates; being the essential form of motion or fluxion in the animal world, 125. It is the parent and measure of the circular; and may be called the perpetual-circular, 126. It emulates spontaneousness in its motion, 126. In the spiral fluxion, the foci are never in the same plane, 128. When nature would so exalt her powers as to return to her own spontaneousness, she betakes herself to spirals and perpetual spirals, 160. A spiral has a circle for a centre, and remotely respects the centre of this circle, 168. Other properties of the spiral, 169. It never returns to the point it started from, ibid. It has the power of infinite variation; and its perfection consists principally in exercising this power, and yet constantly maintaining its own essence, 170. It is capable of adapting itself to every space, ibid. The spiral flexures of the vessels correspond to the tendency to spiral motion in the blood, 437. See *Blood*. The air circulates according to its natural fluxion in the spiral bones of the nares, II., 14. Proofs that the air tends to gyrate spirally, from the spiral cochleæ in the ear, &c., ibid. The perpetuity and perfections of the spiral and

higher forms, 315. In all nature's organic forms we find the idea of continuity, perpetuity, and spiral, 420. See *Pleura.*

SPIRITUAL WORLD, the, holds the physical and material world at its beck and nod, 525.

SPLEEN, the, described by Heister, 328. By Winslow, 329. By Malpighi, 332. Authors to be consulted respecting, 336. Swedenborg's description of, 342. It purifies the blood somewhat in the same manner as the penis, 344. It extravasates the arterial blood into its membranous cells, and there works and reduces it, 345. The great splenic vein, and a host of lymphatics, are its excretory ducts, 347. It undergoes expansion and contraction in the whole and all the parts, 346. It draws off the impure blood from the trunk of the aorta, 348. It discriminates or separates this blood, 351. It receives no serous, but only purely globular or red blood, 353. There is no place in the body for unbinding the blood, but the spleen, 354. The blood prepared by it is a menstruum for the new chyle in the liver, 355. It does not break up the blood-globules, but only separates those that are sticking together, ibid. By its preparation of a sanguineous menstruum, it assists both the liver and the stomach, 356. By its lymph the spleen prepares a menstruum for the chyle in the mesentery, 357. It dispenses its gifts equitably between the liver and the mesentery, 358. While its artery and vein contract, its cells expand; so that no movement of any part is apparent, the incitation being exactly correspondent to the invitation, 359. See *Liver*, *Pancreas.* The purification of the blood may be performed without the spleen, and how, 360. What takes place when the spleen is excised, ibid. See *Omentum.*

STOMACH, the, described by Heister, 109. By Winslow, 111. Ruysch's observations on, 114. Comparative anatomy of, from Swammerdam, 116. From Glisson, 118. Curious particulars respecting, from Schurig, ibid. The stomach digests and absorbs the food, and sends what it has not thoroughly acted upon into the intestines, 122. The salivas, and all the liquids drunk, serve it as a menstruum, ibid. It resolves the salivas into their component spirituous and bodily parts, and makes use of these, ibid. It performs all its operations on its ingesta, by motion, warmth, and delay, 123, 132, 133. Its operations proceed, by degrees, from outmost to inmost, and from both to both at once, ibid. The stomach is active; the food, passive; the saliva, the active medium, 123. The stomach winds in a stupendous and everlasting gyre, ibid. It has poles, axes, and foci, 124. Its form is the spiral, 125. The vortical motion in the stomach of the sturgeon, 125. The structure of the stomach shews the nature of its spiral form, or of its determination of motion, 126. The convolutions of the stomach are analogous to those of the intestines and brains, 127. They have no discoverable beginning or end, ibid. Their general determinations only can be discovered, ibid. The fibres of the muscular coat are spiral; those of the common membrane, circular, 127. The distribution of the nerves, arteries and veins, is according to the poles, axes, and circumferences, ibid. No two of the orifices of the stomach are in the same plane, 128. The motion of the stomach is synchronous with that of the lungs, and runs from the cardia to the pylorus, once during each respiration, 128. Likewise the motions of the lesser forms of the stomach, the orifices of which are minute pylori, 129. The stomach is the centre of all the motions that the lungs pour forth, ibid. The amazing velocity of its motions, ibid. It is composed of lesser stomachs, exercising more perfect and universal offices, 131. These little stomachs receive the materials that have been once digested by the stomach, and digest them more perfectly: again, in like manner, the

least stomachs, 131, 132. And absorb them through their minute pylori and intestines, ibid. The stomach can assume every curve involved in the circular form, 133. The food in it has no gravity or tendency of its own, but is exempted from the laws of the surrounding world, 135. The parts of the stomach are lesser stomachs in respect of function, ibid. The stomach sends its purest products to the brain; the next purest to the blood; the next, to the chyle; the next, to the liver; and none but the refuse through the pylorus, 135, 138. Certainty in these matters is rather to be sought from effects, than from ocular evidence, 136. The stomach, by its absorption, prevents life from being dangerously dependent on the thoracic duct, 138. It throws out the refuse alone through the pylorus, and imbibes all its own chyle itself, 161. It is the principal viscus of the abdomen; and the axis of a wheel, round which the other viscera, and their functions, revolve, 495, 502. See *Peritonæum*, *Saliva*.

SUBSTANCE: see *Motion*. Substances are the subjects of all accidents, II., 306. Forces, motions, operations, and actions cannot be explored excepting through the organic nexus of substances, ibid. Wherever there is a modification, there is a substance also, 524. All causes flow according to the nexus of substances, 525.

SUCCENTURIATE KIDNEYS, described by Heister, 392. By Winslow, 393. By Malpighi, 395. Authors to be consulted respecting, 396. They exercise a sovereignty during the fœtal state, 400. They enjoy an alternate expansion and contraction, 401. Their expansile and constrictile motion converges to their fissure, ibid. Their operation depends on this motion, 403. This motion is synchronous with the heart before birth, with the lungs after birth, ibid. They attract to them certain blood and serum, 404. They are corcula for circulating the serum through the cellular tissues of the peritonæum and its viscera, ibid.; and II., 261. They mingle their blood and serum, and distribute it in various ways, I., 405. Their vein is their excretory vessel, 407. The dark humor in their cavity is an extremely pure extract of the blood, of which a small quantity is capable of converting a large quantity of serum into blood, ibid. They perform an analogous office in embryos to the liver in adults, 408. They regulate the quality and quantity of the supplied maternal and of the fœtal blood, 408. Before birth they divert the stream of serum from the kidneys; after birth, the finer portion of it, 409. They prevent the immoderate seizure of the flower of the blood by the testicles, 411. In long abstinence from venery, they are diverticula to the testicles, 412. They transmit the blood by a short cut from the aorta to the middle of the vena cava, ibid. Why they waste away as age advances, 413. They absorb the pure serum circulating through the pleura, and send it forth in a circle through the peritonæum, II., 261. See *Diaphragm*, *Fœtus*, *Serum*, *Thymus Gland*.

SUCTION. The mode in which successiveness of action conterfeits suction, 98. Minute tubes exercise suction more perfectly than large cavities, 178. See *Tongue*.

SYNTHESIS, one way adopted for discovering truth, 4. The synthetic way passes from the prior to the posterior sphere; the analytic from the posterior to the prior, ibid. Synthesis is nothing but a meagre form of analysis, ibid. It favors our own state and order, and pimps to vanity and self-love; but is contrary to nature, and can never win the goal of truth, 4, 5; and II., 346. It gives rise to errors and civil wars between the soul and the body, and causes the banishment of truth, I., 6.

TASTE, the true objects of, as described by Boerhaave, 30. The conditions of, 30, 31. The varieties of, 31. Touch apprehends parts; taste and smell, parts of parts, 52, 79. The sense of taste is what sets the whole machine of the tongue

and contiguous and continuous organs in motion, 79. The objects of taste consist of parts of the three kingdoms, to wit, the mineral, the vegetable, and the animal, which parts are comminuted and dissolved in their aqueous and other liquid menstrua, and in the salivas particularly, and on being applied to the little sensoria of the tongue, are perceived as to their qualities; the perception or sensation itself, is called taste, II., 567. By the objects of taste, we know the character of the organ, because the two mutually correspond to each other; for the organ represents a common form, whereof the mutations are so many types fashioned exactly to the impressing objects as their ideas or ante-types, 569. Speaking generally, all figured parts, both simple and compound, that have angles and planes, fall under this sense, ibid. But which are naturally so far inert and weighty, that when applied to the little sensoria, they can imprint a type of themselves, and cause a corresponding mutation, 570. And moreover are of such a magnitude, that they can act distinctly upon the individual parts of the organ of this sense, 571. Hence the sense of taste, or savor, is excited by means of fluids, by particles possessing figure, *vis inertiæ*, and just magnitude, ibid. The figures or configurations of parts produce all the varieties and differences of this sense; consequently the sense itself, inasmuch as it consists in variety; but not so the forces of the same parts, or the circumstance that they are intrinsically and naturally inert or active, for the forces only excite the life of that sense, or cause taste to exist. But the measures or various dimensions of parts, merely sharpen or blunt this sense, or render it more or less distinct or obscure, 572. Thus the figures of parts cause sense to be in potency, for all sense consists in variation of modes. The forces of parts cause sense to be in act, or to exist. But quantities prescribe limits to its spheres; and if it transcends these limits, it becomes obscure, or fails from excessive subtlety, ibid. But the larger parts, which do not fall under the sense of taste, or under savor, in the tongue, fall under a sense more akin to touch: and from this mixture of senses, an additional number of varieties and species of this sense arise, which cannot by any means be discriminated distinctly, 574. The papillæ of the third class, conicæ, pyramidales, or villosæ, are the principal sensoriola of taste or savor, 577. What principally distinguishes taste from touch, is, that the papillæ of taste are discriminated, but the papillæ of touch collected; and thus the former bring out their sense separately, but the latter bring out theirs conjointly, 579. But the papillæ lenticulares, as well as the papillæ fungosæ, seem to possess a kind of intermediate or obscure sense of taste, ibid. The cartilaginous bodies that are found in the tongues of certain animals, elevate this common and compound sense to a very great degree, 582. There are three universal species, or superior genera, of the sense of touch, each of which has its allotted regions and provinces in the living body. The first genus, and the most general, prevails all over the circumference, and is properly called touch, 583. The second genus prevails in the innermost parts of the body, beginning from the tongue; namely, in the œsophagus, the stomach, the intestines, and in fine in all the organs of the inferior region, or viscera of the abdomen. This sense, on its first threshold, is called taste, 583. This sense has the office of taking cognizance of, and exploring the whole of what is taken by the mouth for the purpose of serving as nutrition to the body, and principally to the blood, 585. The third genus of this sense likewise prevails in the innermost parts of the body, but beginning from the nares; namely, in the larynx, the trachea, the lungs, and their vesicles; consequently in the organs of the superior region, or thorax. This sense in its first entrance is called smell, ibid. These

are the superior genera of this sense, which speaking generally, is named touch; but with respect to the middle genus, which is properly called taste, it is divided into as many inferior genera, or less universal species, as there are viscera of the abdomen, ibid. These species are divided again into as many particular differences as there are unities in each viscus. So that there are as many specific differences, as viscera; and as many particular differences, as unities, 587. From the variety of the particular sensations of one viscus, a common sensation arises; and from the variety of sensations of many viscera, a still more common sensation arises. And from all and each of these sensations conveyed by the fibres to the cerebellum, the soul, by means of this sense, here apperceives specifically the states of chylification, sanguification, and purification; in a word, of nutrition; and according to the perception, disposes those viscera to the conservation of the whole and the parts, which is the effect and use that this sense produces, 588. But at the first point, where the tongue is affixed to the os hyoides, and is succeeded by the pharynx prefixed to the œsophagus, this sense in a manner flies away, and betakes itself to another sensorium, that is laid in the cerebellum, 589. From taste as existing in the tongue, and the idea thereof perceived in our general sensorium, we may in some measure comprehend how this sense is circumstanced within the viscera, ibid. This sense affects the soul altogether differently to the manner in which it affects the principles of our general sensorium: those things which are delightful to us sometimes affecting the soul unpleasantly; and those which are unpleasant to us affecting the soul with delight; for all things taste according to knowledge and affection resulting therefrom, 591. Moreover in the tongue itself there are few things that fall under our perception or sensation, ibid. The essential and innermost impressions of this sense report themselves to the soul alone, 593. See *Tongue*, *Touch*.

TEETH, the, described by Heister, 61.

TERMS. All new arts and sciences at their first appearance require new terms, 269. Transmutation of terms is necessary when rules are applied to different subjects, 488. The inexpediency of wasting much time or pains upon alterations in terminology, II., 193.

THIRST: see *Hunger*.

THORACIC DUCT, the, described by Heister, 210. By Winslow, 211. By Eustachius, 212. It contracts and propels the chyle, 216. It runs through the general axis of the body, and through mere centres, ibid. Since it passes, therefore, through continual equilibria, it is obedient to every power, whether attractive or propulsive, 217. It follows the movements of the respiration, 217. The so-called valves at its mouth are merely directing planes, 219.

THORAX. The three great cavities of, and the members in them, require to be lubricated with an oily halitus and unctuous milk, II., 270. See *Taste*, *Thymus Gland*.

THOUGHT: see *Ideas*, *Imagination*, *Intelligence*. Experience and science, apart from the faculty of thinking distinctly, are instrumental causes without their principal cause, II., 353. This faculty arises from two orders of conditions, primary and secondary, 354.

THYMUS GLAND, the, described by Heister, II., 266. By Winslow, 267. By Verheyen, ibid. See *Thorax*. It is placed in the middle of the stormy regions of the thorax, and of all the three cavities thereof, in order that it may pour a lacteal unguent into each, 271. It is broken and jagged as beseems a channel for motions and impulses, and why, 272. The cellular tissue surrounding it is a grand and

general duct leading both into the cavity of the pleura and into the cavity of the pericardium, 273. By its suprathoracic portions it anoints the trachea, œsophagus, carotids, jugulars, and great nerves, 275. Its humor anoints only the surfaces, but does not penetrate into the substances and cavities, since it is only an external unguent, ibid. The thymus overhangs and stands at the head of its great cavities and members, 276. The activities of its viscera are the exciting causes that determine the quantity of its excretion, ibid. The latter is not intruded on the viscera, but invited by them, 277. And this also with respect to quality, 278. The state of the thymus in the embryo, 280. The assailant motions of the lungs cause it to waste after birth, and why, ibid. See *Glands*. As life advances, the office of the thymus is distributed to glands on the pleura and pericardium, 282. In the fœtal state, the thymus secreted a serum from the blood, and thus purified the latter, 288. As a corculum, it circulated this serum, and thus served as a companion in office to the succenturiate kidneys, 290. It advanced the purified blood into the veins through a brief circle, according to all requirements, 291. The thymus and succenturiate kidneys are the two chambers of a single serous heart, ibid., and 327. It prepared and laid down a way for the chyle about to come through the thoracic duct, and how and why, 292.

TONGUE, the, described by Heister, 17. By Winslow, 21. By Malpighi, 26. Comparative anatomy of, from Swammerdam, 29, 30. Particulars respecting, from Boerhaave, 30. Authors to be consulted respecting, 31, 32. It involves more uses, ends, and offices, than any other member, 35. Its primary, proper, and natural office, is sucking, sipping, eating, and drinking, ibid. The tongue is a simultaneous body; but its operations are divisible into successive modes and actions, ibid. These successive actions, what, 35, 36. The tongue nourishes the blood by its parts, as the body by its compound, 36. The parts of the tongue perform the same office, not only as the tongue, but as the whole series, from the lips to the anus, 37. The existence of little tongues on the surface of the tongue, confirmed by experience, 36, 37. Tasting is the second office of the tongue, 37. The mobility of the tongue and its parts necessary for tasting, 37, 38. Speaking is its third office, but is not proper to it, 38, 77. Persons have spoken without the tongue, 38. By speech it feeds the mind; by eating, the body, 38, 39. Therefore it is placed in a common relation to the abdomen, the chest, and the cerebrum, 39. It has many other, but derivative, offices, ibid. It does not excrete saliva, but draws saliva to it, from many glands far and near, by suction, 39, 40. See *Malpighi*. All its uses involve corresponding structures; and a fitting order, form, and series, 41. Its muscles so balance it, that it is ever ready to obey the brain, 41. Subdivision of them into external and internal, which respectively belong to the first and second processes of eating, 41, 42. Those of the os hyoides belong to deglutition, 42. The nerves of the tongue come from three sources, and have three uses, 43. The tongue is associated with the internal ear by a branch of the fifth pair, in order that the voice, in its conception, may be in unison with the voice as received by the external ear, 44. The papillæ of the tongue, ibid. The glandulæ fungosæ or capitatæ are organs of imbibition, or nutrition, ibid. They represent the functions of all the members and cavities of first nutrition, 45. The glandulæ lenticulares have a similar but finer and more perfect function, ibid. The papillæ conicæ are sensoria of taste: therefore capable of all possible states and forms, 49. All the other papillæ enjoy a rude kind of sense, 49, 50. There is more of the involuntary than of the voluntary sphere in the tongue, 51. External and internal

causes that affect the tongue, 51, 52. The necessity of graduated membranes in the tongue, 54. Community of affection in all the papillæ thereof, and its cause, ibid. Association of them by their nerves, 55. Necessity of perpetual variety in the tongue, ibid. The fitness of the tongue for its uses is determined by the distinctness of its structures with regard to each other, 57. The extensive field from which further particulars must be gleaned, ibid. The simpler tongues of insects involve the simultaneous performance of a greater number of actions than the human tongue, ibid. The tongue has two means of enlarging the interval between it and the palate; one proper, the other common, 76. When it is about to speak or sing, it conspires with the whole mouth, face, larynx, trachea, and chest, 77. It guides sounds, ibid. When it is about to eat, it conspires with the whole mouth, face, chest, and abdomen, 78. When it is about to drink, the palate particularly conspires with it, 79. The sphere of action of it and the palate extends to the linea alba of the pharynx, 95. See *Taste*.

TOUCH: see *Skin*. Touch expresses and represents the other senses as it were in a grand type, particularly taste and smell; for these senses agree with touch in their fibres or papillæ, II., 447. And taste and smell, like touch, are excited by corpuscules, endowed with *vis inertiæ*, that stamp a figure of themselves upon the little papillary forms, 449. The case is different with sight and hearing, the organs of which are accommodated to the modification of the auras, and therefore do not receive the impulses of inert forces, but the forms of active forces, ibid. Nevertheless these senses,—namely, taste, touch, and smell,—are different from each other in nature and character; this being proved by the origin, degree, effect, and use of each, as well as by the evidence of our own feelings, 450. As well as from the circumstance, that touch is present distinctly in the organs of all the other senses, and governs in a general manner as it were with them as companions, 451. In touch we have also a type of that sensation by which the viscera are affected in their innermost parts, particularly the viscera of the abdomen, as the œsophagus, the stomach, the intestines, the ureters, the bladder; where similar papillary fibres are seen, which are pressed by tactile objects of a not dissimilar character, ibid. Everything in the body derives its life from touch, ibid., and 462. But since the papillary forms of these viscera do not depend upon fibres originating in the cerebrum, but upon fibres originating in the cerebellum, hence the touches in them do not reach the consciousness of the general sensorium, that is, of our innermost sensorium, 453. Touch is commonly excited by contiguous objects that strain the connexion of the parts, and especially of the fibres, in the organic body; or influence their position, order, and series, and thus change and invert their states, properties, and functions, 459. Not only in the papillary cutis, but in every fibrous and vascular texture whatever, particularly in the periostea, the perichondria, the dura and the pia mater, the part under the nails: therefore also in the sensorial organs, as in the tongue, the nares, the ear, and the eye, 462. In the papillary organ of the cutis, as in a mirror, we may contemplate the sense of touch, and see the nature of that sense, and *vice versâ;* the one being exactly represented in the other, 524. We see from this papillary organ, that the papillæ that rise through the foramina of the corpus reticulare, represent the unities of our touch; and that by the mutual apposition of these unities, and their orderly association, an organic form is produced, which is the organ, or as it is commonly called, the sensorium of touch. The scales of the epidermis regulate and temper the sense to suit every use that can possibly be intended in these extremes, 525. From these considerations it appears, that touch is the most obtuse and indistinct of all the

senses; and more obtuse and indistinct in proportion as a larger number of papillæ is pressed, or affected, at the same time, ibid. But this sense may be rendered more acute and distinct in various ways; nay, it is actually more distinct wherever use demands it, 527. In touch, as in all the other senses, there is first an impression, involving in it an action, either from some inert, or from some active force, that comes from without. Next, answering to the impression, a mutation in the excited part of the sensorial organ; and hence a reaction corresponding to the action. Then a perception of the mutation in the general sensorium, giving rise to a sensation. Forthwith, according to the perception, there arises an affection: according to the affection, a disposition to the preservation of the part or the whole; or a change of state in agreement with the affection: then an effect embodying the use that the sensation produces, 528. The papillæ are expanded, extended, and soften, when they come in contact with a pleasant object; but are constricted, retracted, and harden, when they come in contact with an unpleasant object, 531. Whatever soothes the parts and cements their union, is pleasant; but whatever twinges and destroys, is unpleasant, 532. The objects that imprint their image upon the papillary organ, or induce mutations upon it, are many in number, both bodies or substances, and accidents and modes, with their degrees and momenta: to wit, all things whatever that change and affect the natural state of the organ or its parts, 533. In order that objects may be properly known, touch is instructed by sight, and *vice versâ*, sight by touch, 535. Besides the affections arising from external sensations, there are also affections from internal causes, which vary our senses, and touch particularly, in a singular manner, 538. Touch, like the other senses, does not indicate the essence, form, and nature, that objects have inwardly, but only that they have outwardly; consequently only their figure or external form; wherefore experience, art, and study are necessary to explore these objects more thoroughly, 539. Each papilla, which represents a unity of our touch, consists of fibres, or simpler papillæ; consequently each unity of our touch arises from other most minute unities, 541. From these fibres, which are the parents or unities of the papillæ, the sense of touch derives its distinctive generic character, 542. The objects of touch induce mutations not only upon the common series or form of the papillæ, but also upon the parent fibres of each papilla; and in fact more considerable and distinct mutations in proportion as the organic forms are more perfect, 543. We may see by calculation how many myriads of mutations constitute one particular of touch, 547. The mutations that exist among the fibres in each papilla, give the real essence and life that there is in this sense, 548. These mutations that exist within each papilla, are most distinctly presented to the soul, which alone gives the power to feel; and this, according to the organic form in which the soul has disposed and combined the fibres and papillæ, 549. From these considerations it is manifest, that the sensorio-organic form of touch is twofold: namely, one form simple, the other compound; and that the compound arises from the simple: but yet, although the form appears double, it is nevertheless one in this respect, that both its elements together produce this sense. Also that the simple or fibrillary form immediately refers its modes of sensation to nature, or to the soul, in which that nature is involved; but that the compound or papillary form immediately refers its modes to the general sensorium, or to our understanding, to which such sensorium is assigned, 550. The soul has so organized the body, that it, namely, the soul, is conscious by means of the senses, and by means of touch particularly, of whatever happens in its extreme, that is, outermost and innermost spheres, as well as in its intermediate sphere; in order that from the first moment of

bodily life to the last, it may keep all and singular things under its auspices, and dispose them according to contingencies, ibid. If any particle in the living fabrics of the body be destitute of the sense of touch, it is also destitute of life, 554. The uses of touch are, to perceive all changes of state occurring in the circumambient world, and communicate them to us: and thus to keep both watch and ward; to notice whatever happens, and by means of its organ placed on guard, to protect, at the same time that it institutes communications, 555. To announce to the understanding whatever comes in contact with, assails, or beats against the skin; what it is, its quality and quantity, and where it comes from; so as to allow that faculty, from the evidence of the impression, to judge of what is intended; and at the same time to put the body either in a state of protection, or in a way of taking advantage of the thing, and receiving benefit from it, 556. Touch also admonishes the organs of taste and smell of the existence, quality, and quantity of that which is either taken in openly, or glides in furtively, and which those organs are shortly about to explore in a different manner by their senses, ibid. That those which appear to be the ultimate qualities inherent in things, may be known, and be denominated, according to this sense, and its perceptions and affections, 557. To announce to the soul the subtle particles that wash against the little mouths of the pores of the skin, and that will serve as aliment to recruit the organic principles, and therewith the higher life of the body, 558. That the parts, and the series constructed of parts, or the members, may be excited by the irritation of touch, both to undertake and go through their functions, 559. See *Taste*.

TRACHEA. Described by Heister, II., 87. By Winslow, 88. Particulars respecting, from Morgagni, 91. From Boerhaave, 92. There is no difference between the trachea and the lungs, except such as there is between the general and the parts, or between continuous and discriminated quantities, 93. The proper uses of the trachea are the common uses of the lungs and the larynx, 94. The trachea affords a channel for the atmosphere, and for the breath of the lungs, to pass and repass, and accommodates itself to all the numerous and diversified modes of action of the lungs, both in inspiration and in expiration, 95. In no part do so many motions meet as in the trachea, 96. Its cartilages may be termed the cervical or tracheal ribs, 99. It examines and corrects the air that is about to pass into the lungs, and prevents anything hurtful from entering, ibid. In moistening the trachea, as in all nature's operations, there is a general and a particular, viz., general and particular glandular springs, 100. It impregnates with vapors the air that is passing out: thus it entangles effete exhalations, and prevents the contiguous parts from being injured thereby, 101. The trachea likewise in a general manner clears the lungs from viscid phlegm by expectoration, ibid. It serves as a pillar and support to the larynx; and adapts itself exactly to the beck and nod of the latter, and to its tremulous vibrations, 103. It disposes the parietes of its canal, so that the air may impinge upon them; and stretches or tightens its membrane, so that when the air impinges the membrane may tremble; and thus excites the rudimentary sound, for the larynx afterwards to form into singing or speech, that is, to modify, 104. In the trachea, the tremblings proceed according to true natural order, from purer to grosser, correspondently to the membranes, 105. It moistens the larynx continually with a vapory dew, 106. It aids and assists its neighbor, the œsophagus, in the office of deglutition, 107. The reason why the tracheal nerve is recurrent, and why the par vagum does not immediately approach the trachea, 109. The

trachea divides and shares the salivary humor proceeding from its springs, in just proportion between itself and the œsophagus, according to the necessities of each, 110. It is the grand œsophageal salivary gland, 111. It pours the alternate respiratory motions of the lungs into the neighboring parts, and thereby into the remote and ultimate parts; namely, into the œsophagus, and thereby into the stomach, and so into the viscera of the abdomen: also into the great sympathetic nerves,—the intercostal and the par vagum: and into the ascending carotid artery and the descending jugular vein; and thereby into the universal system: thus it renovates the motive life of the body, 111—116. It insinuates into the neighboring parts, and thereby into all other parts, high and low, its own sonorous tremblings, as well as those of the larynx: thus it excites the arterial blood mounting to the head and brain, and the venous blood returning from the head and brain, together with the ear, the companion in office of the trachea, and exhilarates and animates them by a general modification: thus it renovates the sensual life of the body, 116—119. See *Blood.* The tremblings propagated from the larynx and trachea are the most intense where the thoracic duct enters the subclavian vein, 119. The trachea represents in itself, as in an image, how every member of this body or kingdom lives for all the other members, and not for itself alone, ibid.

TRINE: see *Series.*

TRUTH is the source of wisdom, 1. Every truth is a combination of an infinity of other truths, 2. The more numerous the truths that go to form one truth, the brighter is its light, ibid. A truth is never opened without an infinity of others being opened also, 3. Truth in man is according to his order and state; hence the truths in the rational mind do not deserve to be called truths, but principles, ibid. Two ways for discovering truth; synthesis and analysis, ibid. See *Analysis, Synthesis.* The power of perceiving truths *a priori* belongs to God and spiritual beings, but not to man, 6, and II., 346, 352. In proportion as we ascend to truths by the proper means, truths descend to us, I., 8. Purity of mind and respect of universal ends are necessary for the discovery of truth, 8. Plato's experience on the subject, 8, 9. Even the truths legitimately explored by analysis are only appearances of truth, 9. The soul is in the sphere of truths, 10. The signs that accompany the truth to them that receive it, II., 360.

UMBILICUS. It is a centre of gravity to all the tunics of the body, 466.

UNITIES, what; exemplified in the muscles and glands of the tongue, 53. All things are related to their unities, ibid. Any series may be assumed as a unity, ibid. See *Leasts, Organic Forms, Simples.* Every form or series has its proper unities, II., 465. All accidents, modes, &c., have their unities, 467. Unities are noble in proportion to the priority and height of their origin and extraction, ibid. Unities are not to be understood as indivisible, but as those things that are the least in each series, and enter its form as its essential parts, and which are proper to it, and would not suit any other series or form if they were applied to it, 466. Different kinds of unities may coexist in one viscus, ibid., and 482. It is impossible to arrive at a knowledge of the use of the viscera, unless at the same time of their unities, 467. Unities are predicated of the greatest things as well as of the least, 468. The unities of human society are men, thus entire bodies; the unities of the muscular system are entire muscles, ibid. Unities generally ascend to the third series of composition, but sometimes rise no higher than the second, sometimes as high as the fourth, 470. Compositions are homogeneous with their unities, 475. See *Contiguous Things.*

Effects and operations go no higher than to unities, and from them, 482. Unities are centres, wherever in their viscus they are situated, 485. The fibres with the vessels infuse into the unities of organs their *posse* and *esse*, or potency and essence, 490.

UNIVERSAL: see *General.* Every universal derives its nature from singulars, 194. A universal is that which exists and acts universally in the whole, and in all parts of the whole, 487. In the human microcosm the soul is such a universal, 488. Every whole has its proper superior universal, inferior universal, and ultimate universal, ibid. The three universals in the human body, what, 489; II., 425, 446. The mode of derivation of the lower and lowest universals from the higher, what, I., 489; II., 446. The universal gives the essence, and determines it; the common bond defines and bounds it, I., 492. In proportion as essences are pure, they are universal and abundant, II., 434. There are three universal essences that govern the body, viz., the soul, the animal spirit, and the blood, 440. See *Skin.*

UNIVERSE. Everything in its first principles represents the universe, 173. The body is a kind of universe, 193. See *Leasts, Microcosm.*

URETERS, the: see *Kidneys.*

URINE: see *Kidneys.* It is continually varying in all its conditions, 454.

USE must be the first object of enquiry, since all things are formed according to use, 33, 429. The use, as the end, first of all manifests itself, since it is continually present and involved in the series of progression, 34. Use determines the harmony of varieties, 56. A superior universal use is always ultimately respected, 240. All parts are organized for use and by use, 301; II., 462. The use determines and unfolds the reason of the structure; but the structure, apart from the use, does not give a reason for itself, save as interpretable by examining numerous effects and causes in series, I., 341. The circle of uses, what, 375, 378; II., 141. The series and circle of causes involve a corresponding series and circle of uses, I. 377. See *Cause, Effect, Efficient, End.* There is a similar progression of uses as of effects, ibid. See *Circle.* Every point in creation flows from a use, and tends to a use, 381, 409. If the use of a viscus be unknown, its structure must be opened, and the use interpreted therefrom, and how, 431. If the use be known, we must then enquire into the series of subordination existing in the cause, ibid. All things should be examined not only with a view to their situation and connexion, but also to their particular uses, 462. We are to enquire how use brings forth use, since there is a chain of all things, II., 141. Such is the progression of uses, that effects return by an incomprehensible gyre to their first end, 362. Were it not for the animal kingdom, nothing that the terraqueous world produces could be said to minister a use, 362. The cuticle is modified in exact correspondence to use, 393. In unfolding uses, we must take account of contents as well as continents, 430. See *Organic Forms.* There are as many mirrors of uses, or of progression from the first end to the last, as there are organs and viscera, and parts thereof, 464.

UVULA, the, described by Heister, II., 4. By Winslow, 8. It gives the velum palati full power of accommodating itself to the actions of the tongue and pharynx in eating and swallowing, 36. It assists the velum when the larynx is articulating and the tongue regulating sound, 37. Why not found in brutes, ibid. It determines the humor of the nares towards the pharynx, ibid.

VARIETY: see *Distinction, Kidneys, Organic Forms, Tongue, Urine.* No society can exist among absolute peers or equals; there must be a perpetual diversity of members, II., 363. The amazing variety of the perspirations, II., 391, 416. Unity supposes variety, and perishes in equality, 478. One thing joined to another

with becoming variety, remarkably exalts the life of sensations, 533. The sensoria are fashioned for infinite varieties, ibid.

VEINS, the generation of, in the subcutaneous glands, II., 417, 418. Their passive and female nature, 417. See *Arteries*, *Vessels*. The veins demand back the embodiment of the blood, I., 447. See *Lymphatics*.

VENA PORTÆ, the, described by Heister, 256. It is a sewer and turbid gulf of humors, 279. It divides them into three species, 281. See *Liver*.

VESSELS, the coats of the, and their fluids, are mutually determinant of each other, 219. Where the vessels end, there they also begin, 283. See *Arteries*, *Veins*.

VISCUS. Any state or animus induced on the brains, is induced on the fibres, and hence on the viscera, 139. There are as many spheres as viscera, 193. All the viscera are chemical organs, 235. All viscera designed for the separation of concreted particles, require to be divided into lobes, united by ligaments, and parted by fissures; in order that everything may be done tranquilly, 296. Those viscera that are employed generally in a similar office, constitute corporations, 429. The viscera take different and unequal quantities of blood, 430. The mutability of state of the viscera, ibid. The use of many viscera is shewn by their ultimate effects, not by their structure, ibid. The abdominal viscera are analogous to the earth; the thoracic press and actuate them as the atmospheres press and actuate the earth, 526.

VOICE. Distinction between sounding, singing, and speaking, II., 50. Change of voice from puerile to manly, 77.

WILL: see *Nature*, *Soul*. The will acts for the most part from the decrees of the senses, the blood, or the body, 205. The will alone is ours, 397. The quality of an individual, when predicated of himself, is predicated really of his will, 397. All the voluntary motions are actions different from natural action, II., 102. If the will alone ruled, all things would perish in less than a moment, 338. The will is free, 365.

WINSLOW, THE FORAMEN OF. The spot where it is situated is the common hinge of the abdominal viscera, 386. The exudation given out there, diffuses itself continuously along all their coats, ibid. This spot is the centre of the motions of the viscera, ibid.

WORLD. The world sustains the orders and states of our bodies, as a common auxiliary, II., 386.

APPENDIX.

AN ACCOUNT OF SWEDENBORG'S PHYSIOLOGICAL MANUSCRIPTS IN THE LIBRARY OF THE ROYAL ACADEMY OF SCIENCES OF STOCKHOLM. BY DR. J. E. SVEDBOM, LIBRARIAN TO THE ROYAL ACADEMY OF SCIENCES OF STOCKHOLM, PH. D., A.M.

THE following statement is the result of an investigation undertaken for the purpose of replying to Mr. Wilkinson's question,—"Whether the MSS. of Swedenborg, enumerated in the preface to the 'Animal Kingdom' (pp. xiii. and xiv.), are to be found in the Library of the Royal Academy of Sciences of Stockholm?" It appears best to give an answer to the particular details of the question separately, adding certain bibliographical observations, in order to enable the reader to form an idea of the contents and size of each manuscript, and of the amount of labor necessary for transcribing it.

1. *Fragments on the subject of the Economy of the Animal Kingdom, and on the subject of the Animal Kingdom itself, among which is a Treatise on the Parts of Generation in both sexes, and on the process of Generation.*

Among Swedenborg's manuscripts preserved in this library, there is one in folio, the title of which, a considerable portion of the beginning, and the end, are wanting; but the matter seems to agree with the title given above. This book contains various treatises, each with some number and title prefixed to it. The leaves are not regularly numbered, but distinguished in some cases by numbers, in others by letters. The book begins with a page marked U U, in the middle of the twenty-second treatise, as it would appear from what follows. The other treatises, of which but little seems to be wanting, are as follow:—23. The Periosteum, p. vi. 24. The Mammæ, p. xii. 25. The Ear and Hearing, p. xxix. The end of this treatise is wanting, together with the title and beginning of the next treatise, but which, to judge from what is left of it, seems to have been headed,—26. The Eye and the Sense of Sight. Of this treatise there remain p. xl., but the end of it is wanting. 27. The Spermatic Artery, p. x. 28. The Testes, Epididymes, &c., p. xv. 29. The Scrotum, p. v. 30. The Vasa Deferentia, p. vi. 31. The Vesiculæ Seminales, p. xvii. 32. The Prostate Gland, p. vii. 33. The Urethra, p. viii. 34. The Penis and Corpora Cavernosa, p. xvi. 35. The Semen, p. viii. 36. The Membra Gen. Mulierum ext., p. xi. 37. The Uterus, p. xvi. 38. The Ovaries, p. iv. 39. The Fallopian Tubes, p. viii. 40. The Uterus (a second treatise), p. xiii. 41. The Placenta, p. xv. 42. The Chorion, Amnion, and Liquor Amnii, p. x. 43. The Umbilical Cord, p. ix.

44. Conjectures respecting the State and earliest Stages of the Embryo, p. vii. Next we have, in the same volume, various excerpts from the works of other authors respecting certain animals.

The heirs of Swedenborg, who delivered his books and manuscripts to the Royal Academy of Sciences, in the catalogue which accompanied their letter of donation, state that the above treatises are fragments of the books entitled "Œconomia Naturalis" (so they write it), and "Regnum Animale." In the course of reading and comparing, I have found that the style of treatment is the same as that adopted by Swedenborg in his "Œconomia Regni Animalis;" in so far as this at least, that the facts and experiments of the learned are first premised, and the author's own sentiments unfolded afterwards, under the heading "Induction."

The greater part of the contents of this volume is closely written, and will be difficult to read or make out.

2. *The Animal Economy, (consisting of Treatises respecting both parts of Man, respecting the Cerebrum, the Medulla Oblongata and Medulla Spinalis, and respecting the nerves,*) considered analytically, physically, and philosophically*, &c., p. 760.

There is a book in 4to. bearing this title, but the title is crossed out with the pen, and does not seem to correspond with the contents of the book. Thus the latter contains, in various places, the Author's Diary [*Itinerarium*] from 1733 to 1739, with a brief description of his travels from 1710, written partly in Latin, partly in Swedish: also extracts from various authors on physical and philosophical subjects: a treatise on "The Mechanism of the Soul and the Body," respecting which see below (3), &c. It appears from the Catalogue mentioned above, that this volume once contained 760 pages, whereas it contains now only 714.

(Respecting the treatises which we have elsewhere, written by Swedenborg, on the "Cerebrum," &c., see below under the head Additions I. and II.)

3. *The Mechanism of the Soul and the Body.*

The treatise to which this designation refers, is found in the volume last mentioned, of which it occupies pages 116 to 131. It is written, in places, in a hand somewhat difficult to read. From the kind of writing, I should infer that this treatise is only a sketch [*adumbrationem*], and not digested into the form of a fully developed work.

4. *The Animal Spirit*, p. 24.
5. *Sensation, or the Passion of the Body*, Chap. XIII.
6. *Action*, Chap. XXXV.

In the 4to. volume (2), we find these three little treatises, as well as certain others. The first on "The Animal Spirit," is in 24 pages, and XVII. Chapters. The second, on "Sensation, or the passion of the Body," is in 11 pages, and XIII. Chapters; but it ends with the heading, Chapter XIV., which would lead one to suppose that the subject was not finished. The third, on "Action," is in 30 pages, and XXXV. Chapters, and appears to be complete. These little treatises are easy to read and make out.

(Respecting the other treatises that are contained in the same book, see below, Addition III.)

* It appears that Swedenborg published a little work on this subject, entitled, "Dissertationes duæ de Fibra et Succo Nervoso," 8vo., Rome, 1740.—(Tr.)

7. *General Sense, and its influx into the Soul.*

I find this title given in the Catalogue already referred to, as belonging to some "Fragment" preserved among the manuscripts of Swedenborg; but in the course of my examination, I have not been able, at this time, to discover any treatise so entitled in the manuscripts.

8. *The Muscles of the Face.*

9. *The Human Ear.*

These are two treatises having the above titles, both contained in one volume folio.

The treatise on the "Muscles of the Face" contains 13 pages and various chapters, headed separately: as for example,—"The Muscles of the middle region of the Face;" "The Muscles subservient to the Nose," &c. This treatise, however, has not the appearance of being fully carried out, but seems rather to contain the outline of some projected dissertation. It is closely written.

The other treatise, on "The Human Ear," is in 11 pages. It appears, however, that this treatise, although written by the hand of Swedenborg, is not of his composition, but consists only of certain excerpts from a work by J. F. Cassebohm ("Tractatus VI. de Aure Humanâ," Halæ, 1735). But there are two manuscript treatises by Swedenborg himself, on the same subject, in other parts of this collection, but with different titles. The one, "On the Ear and Hearing," of which mention was made above (1); the other with the slightly different title—"On the Ear and the Sense of Hearing;" and which latter is found in the volume of which we are at present speaking. (Respecting this second treatise, see Addition I.)

ADDITIONS.

I might here have brought this Memoir to a close, having given answers to the best of my ability, to all the particulars of the question proposed. But I hope it will prove agreeable and acceptable to the London Society, by whose efforts and labors so many of the writings of Swedenborg have been published; and particularly to Mr. Wilkinson, who is now engaged in publishing a translation of the "Animal Kingdom," if I proceed a little further, and record certain observations I have made in examining the MSS. of Swedenborg, and which have a close connexion with the design of the London Society,* and of the Translator of the work already alluded to.

I. While occupied in scrutinizing the MSS. of Swedenborg, (which have never yet been satisfactorily examined, nor indeed could be, until they were better arranged,) I chanced upon a manuscript, with neither title nor termination, but which, nevertheless, powerfully arrested my attention. Like many others in the Library Catalogues, this book was classed under the general designation "Anatomica et Physiologica," along with the rest, without any indication of its subject matter; nor was there a trace to shew, that any searcher of the MSS. had hitherto turned his attention to it. Throughout, as I perused it, and considered the contents, I was led to the notion that it contains a CONTINUATION OF THE "ANIMAL KINGDOM," *unknown to exist, so far as I am aware, up to the present time!* And although I am not sufficiently versed in Swedenborg's writings, to affirm with certainty that this conjecture is well founded, yet thus much I will say, that it has grown in probability in

* Dr. Svedbom is not aware, that the "Society for Printing and Publishing the Writings of Swedenborg, instituted in London in 1810," is exclusively occupied in the publication of the Theological Works of the Author, and does not, as a body, take cognizance of any other department in Swedenborgian Literature.—(Tr.)

proportion as I have examined the book, and compared it with the treatises which Swedenborg himself published on the subject of the "Animal Kingdom" in his lifetime. This book is in 241 closely-written folio pages. It begins with p. 1, Prologue, the subject matter of which is remarkably similar to that of the Prologue prefixed to the "Animal Kingdom," Part III. (London, 1745); although the two do not coincide verbatim; the manuscript Prologue being much fuller and longer than the other. The treatise which follows, from p. 3 to p. 241, seems to embrace not only a summary of the subjects contained in the "Animal Kingdom," Part III., (briefly stated however, and only the results indicated,) but also a good part of those subjects which the Author, in the Index of Contents of the whole work prefixed to Part I., promised the reader that he intended to treat of, but which he did not develop in the three parts which he himself published. In proof of this, we have the following titles prefixed to the several treatises. After the Prologue, which stands as n. I., we come to II. The Common Trunks of the Carotids; the External Common Branch of the Carotid; The first External Branches of the Carotid; The other External Branches of the Carotid. (These subjects occupy p. 3—11.) III. The Sense of Taste and the Tongue; Sense in General;* The Sensorium of Taste in General and in Particular (p. 12—31). IV. The Sense of Smell† (p. 32—43).‡ The Sense of Touch, or the Layers of the Skin [*cuticulis*] (p. 44—60). The Ear and the Sense of Hearing (p. 61—83, with additions on p. 99). The Eye and the Sense of Sight (p. 84—121), in which we have various sub-titles; for example, Light and Colors; the Muscles of the Eye; the Coats of the Eye, &c. Next follow, commencing from p. 122, Physical and Optical Experiments, whether by Swedenborg himself, or extracted from the writings of other authors, I cannot say. Epilogue, on the Senses, or on Sensation generally (p. 129—150). And afterwards, In brief, A General Statement of the Subjects of Sensation and Affection (p. 150—159). Next, A continuation respecting Harmonic or Musical Laws (p. 160—187). In the course of which we have a treatise on Speech (p. 185—187); next, The Understanding and its Operation (p. 187—196); last, an Index to the preceding, filling four pages, but which are not numbered. Then follows, Preface to the Part on the Brain, but prefixed immediately to the first chapter (p. 198—202); also Chapter I. The Brain, its Structure and Motion, and Sensation generally (p. 202—204). The following heads occur on the last-mentioned page (204):—Chapter II. The Cranium, and the Bones of the Cranium. Chapter III. The Dura Mater, and the power (?) of production, and so forth; without any development of the subjects indicated. There is next a continuation of the dissertation on The Structure of the Brain (p. 206—209); The Functions of the Brain (p. 209—232); and a Summary of the same (p. 232, 233). The Dura Mater (p. 234—241).

The several treatises to which the above titles refer, do not appear to be finished productions, fully reasoned out, but rather to be outlines, which the author intended to develop farther at a future time, and digest into formal dissertations. Notwithstanding this, the author's opinion, unless I am mistaken, is for the most part

* A note of the author is here appended, written, as it appears, subsequently to the treatise, and in the Swedish language, stating that this chapter is to be transferred from its present situation to the Epilogue, since such explication in this place would be contrary to the "analytic method." (J. E. S.)

† The "Sense of Smell" was to have been the subject of "the very next Chapter" in the "Animal Kingdom," had Swedenborg continued the Work. See Vol. II., p. 585, note (q). "Hearing" and "Sight" would probably have been the next subjects, completing Part III.; and the "Cerebrum" was intended to be the subject of Part IV. The manuscript on the Cerebrum, according to Dr. Svedbom "contains a development of the subject," and is "accurately written out," so that Swedenborg would seem to have prepared it for the press.—(Tr.)

‡ The Roman numerals prefixed to the titles, cease in this place. (J. E. S.)

sufficiently unfolded to be perfectly apprehensible. The style of treatment is the same as that peculiar to Swedenborg in the former parts of the "Animal Kingdom;" there being first a statement of Experience, and after this, an Analysis. The first department of each treatise, containing the Experience, is very brief; nor are the passages from the authors quoted, written out, as was Swedenborg's custom elsewhere in these essays: but the second department, or the Analysis, is much longer and more full. With respect to the hand-writing, the greater part of this book is written very small, and is extremely difficult to read and make out; so much so, that it would task the best abilities of the copyist to perform his part correctly.

From these particulars, unless I am deceived, there is ground to hope, that this book, in conjunction with that mentioned above (I.), contains many things that will hereafter prove supplementary to Swedenborg's "Animal Kingdom."

II. It will be recollected that the subject matter of the manuscript entitled The Cerebrum, &c. (2), greatly disappoints the expectation raised by that title. On the other hand, from what has just been said, it appears that another volume, lately mentioned, presents the disappointed and almost unhoping reader, with a Dissertation on the Brain and its functions. But as this Dissertation, like all the others in the same book, seems to give nothing more than an outline of some future treatise, it will perhaps be agreeable to the reader to be informed, that I have found two other books, which seem to contain a development of the subject of the brain, accurately written out. Both these books are indeed incomplete, being destitute of begining and termination.* The greater part of them, however, appears to be left: and certainly quite enough to merit the close attention of the enquirer. Thus the one MS. has on the Brain pp. 65—433; the other, which is much the larger, pp. 73—1482.† Both are in quarto, carefully written out, and not difficult to read; the latter more diffuse in its style of penmanship, and with somewhat wider lines than the former. But I have not yet had leisure to compare these books with each other, or with the above-mentioned outline; and therefore I can only mention them here, and must postpone the more accurate examination of them till another time.

III. In the manuscript mentioned above (4—6), there are certain matters which should not be passed over without notice; among these we have the Red Blood (p. 24, chap. xxiii.) The Origin and Propagation of the Soul (p. 6, chap. iv.) At the end of the same MS. a longer treatise begins, but both its title (p. 1 and 2) and continuation, are wanting. After a short preface, which occupies p. 3 and 4, we read on p. 5 the following:—

Treatise I. The Soul, and the Harmony between it and the Body, considered generally.

The work begins with these words, "The Mind never really acquiesces in any system concerning the intercourse and harmony between the Soul and the Body, that supposes the existence of an unknown and incomprehensible principle," &c. The treatise ends on p. 80, in the middle of a sentence. The leaf containing p. 7 and 8 is wanting. In the preface at the beginning, the Author says, "Kind reader,

* This, I find subsequently to be an error; the second and larger Treatise appears to be complete with respect to its termination.—(J. E. S.)

† The probability is, that the beginning of these Treatises has been inserted in the "Economy of the Animal Kingdom," tr. ii., chapter ii., n. 69—207, "On the Cortical Substance of the Brain specifically;" and should this prove to be the case, then the larger Treatise may be regarded as quite complete.—(Tr.)

—I was long in doubt whether to bring together in one volume or work, the result of all my meditations on the Soul and Body, and the mutual action and passion of the two; or whether to divide my labors into separate numbers and treatises, and to publish them, one by one, in the shape of Transactions." He goes on to say, that it would be a "labor of many years," and would "require volumes" to explain the soul and the state thereof, together with its intercourse with the body, and the connexion between the two, by means of harmony; that is to say, "to set forth the whole animal kingdom with all its parts, and the functions and offices of each, philosophically, analytically, geometrically, and anatomically." As he foresaw that it would be impossible to finish this immense work satisfactorily at a single blow, he deemed it most advisable "to divide it into treatises and numbers, and to publish frequently." He promises, therefore, that he will come before the reader often; perhaps not less than five or six times a year, and that the fasciculi of his work will be issued under the title of "Psychological Transactions." At the end of the preface, the author signs his name, *pseudonymice*, J. S. E. G. O. F.

I leave the character and number of these Psychological Transactions, if they be identified with the parts published and unpublished of the "Animal Kingdom," to be determined by those who are more versed than myself in the writings of Swedenborg.

Such are the particulars which I have hitherto observed in going over the manuscripts of Swedenborg. It will be a matter of the greatest gratification to me if the preceding statement contains any novelty, or anything that is worthy of the kind consideration of those who are laboring so earnestly in the publication of Swedenborg's works.

J. E. SVEDBOM,
Doctor of Philosophy and Master of Arts.

Stockholm; the Library of the Royal Academy
of Sciences, December, 1843.

CORRECTIONS IN THE WORK.

Vol. I., page 18, line 15 from the bottom—for, "of different sizes," read, "large and small."

Ibid., page 78, line 3—for "The keys may produce everlasting harmonies from these principles, without ever exhausting the source," read, "From this source the keys can draw forth their science without ever exhausting it."

Ibid., page 110, line 10 from the bottom—after "animals," insert, "so that I have no longer any doubt respecting them."

Vol. II., page 10, line 8 from the bottom—for "with them, the nasal passages are blocked up, and all respiration that way is intercepted," read, "with them, when the nasal passages are stopped up, all respiration is intercepted."

Ibid., page 294, for φρην read φρενες.

INTRODUCTORY REMARKS BY THE TRANSLATOR.

It will be the aim of the following remarks to give a general view of the doctrines of the "Animal Kingdom," and of their relation to the past, present, and future state of science; and in so doing, to address those chiefly who are acquainted with the theological writings of Swedenborg, as forming the class by whom, at present, the work is most likely to be read, and to whom it may be the most useful and satisfactory.

The evolution of the natural sciences amounts to the creation of a new sphere in the human mind; and since this development has not taken place under the auspices of theology, but either in direct or tacit opposition to the prevailing church; since it proceeds from without, and proposes knowledge and intelligence as ends distinct from spiritual life; therefore it constitutes a sphere which is not in unison with the current doctrines of religion, but from the beginning has menaced their subversion; and which, unless reduced to order, is opposed, however true its materials in themselves may be, to the understanding of all genuine truth. It was a perception of this character in science, and also of the fact that the universal human mind was becoming immersed in scientifics, that impelled Swedenborg to enter the field of nature, for the purpose of demonstrating in it an order corresponding to the order of heaven, and thereby of making it a medium to spiritual and sacred truths. This was his paramount end in the construction of the "Animal Kingdom."

The system therein propounded rests upon the foundation of experience; namely, of such experience as the learned world had accumulated at Swedenborg's time; not indeed upon the particular experience strictly and proximately belonging to any one science; for such experience would be inadequate, in the present imperfect state of our insight, to suggest the universal truths that each science involves; but upon the general experience of all ages in all the sciences. This, it is to be presumed, was Swedenborg's meaning, when he likened himself to one of the racers of olden time, who before he could merit the crown, was commanded to run seven times round the goal; and again, when he declared that we must be instructed by all things of one thing, if we are to know that one thing thoroughly. As his theory is not derived from particular experience, so it cannot finally be either confirmed or denied by any isolated fact or facts. For it is a conclusion from the order and tenor of facts universally; in a word, from an integral survey of nature. Unless this be borne in mind, the very largeness of the field from which his inductions are drawn, and the very strictness of mind which caused him to test them through all the sciences, will only make them seem the more like baseless hypotheses. In this case the analytic process may easily be mistaken for the synthetic, and Swedenborg may be charged with committing the error which he begins his work by denouncing in others.

Swedenborg announced the starting-point of his method in the first lines of his first chapter; namely, that "the use or effect which produces the end must be the first point of analytic enquiry." First comes the question of fact or result; next, the reasoning upon it. Unless we reason from uses, what chart have we in the exploration of structures? To illustrate this, let it be supposed that a complicated tissue—for instance, the skin—presents us with three undoubted effects, say of absorption and excretion; from these effects we infer the existence of a threefold organism to produce them; for effects imply causes, and functions, forces, motions, accidents, &c., are predicates and unvarying signs of substances. Having proceeded so far, we have then to distribute the effects to their proper organic causes in the tissue; and thus effects furnish the rule for the first analysis of a structure. In many instances indeed it will be im-

possible to trace effects to visible organic causes, in which case the mental sight must take up the operation, and continue and complete it, and this, by the assistance of the several instruments and appliances which are now to be mentioned.

It is impossible to understand either the Word or the works of God without doctrines, which in both cases require to be formed by "one who is enlightened."* The doctrines made use of by Swedenborg in the "Animal Kingdom," are the Doctrines of Forms, of Order and Degrees, of Series and Society, of Influx, of Correspondence and Representation, and of Modification. These doctrines themselves are truths arrived at by analysis, proceeding on the basis of general experience; in short, they are so many formulas resulting from the evolution of the sciences. They are perpetually illustrated and elucidated throughout the "Animal Kingdom," but never stated by Swedenborg in the form of pure science, perhaps because it would have been contrary to the analytic method to have so stated them, before the reader had been carried up through the legitimate stages, beginning from experience, or the lowest sphere. Each effect is put through all these doctrines, in order that it may disclose the causes that enter it in succession, that it may refer itself to its roots and be raised to its powers, and be seen in connexion, contiguity, continuity, and analogy with all other things in the same universe.† They may be compared to so many special organs, which analyse things apparently homogeneous into a number of distinct constituent principles, and distribute each for use as the whole requires. To deny any of these doctrines, or to give them up in the presence of facts that do not range upon them at first sight, is to nullify the human mind as the interpreter of nature.

The Doctrine of Forms teaches that "the forms of all things, like their essences and substances, ascend in order and by degrees from the lowest to the highest. The lowest form is the angular, or as it is also called, the terrestrial and corporeal. The second and next higher form is the circular, which is also called the perpetual-angular, because the circumference of the

* Arcana Cœlestia, n. 10582.

† By a universe, Swedenborg appears to mean any complete series as referable to its unities.

circle involves neither angle nor rectilinear plane, being a perpetual angle and a perpetual plane; this form is at once the parent and the measure of angular forms. The form above this is the spiral, which is the parent and measure of circular forms, as the circular, of angular forms. Its radii or diameters are not rectilinear, nor do they converge to a fixed centre like those of the circle; but they are variously circular, and have a spherical surface for a centre; wherefore the spiral is also called the perpetual circular. This form never exists or subsists without poles, an axis, foci, a greatest circle, and lesser circles, its diameters; and as it again assumes a perpetuity which is wanting in the circular form, namely, in respect of diameters and centres, so it breathes a natural spontaneousness in its motion. There are other still higher forms, as the perpetual-spiral, properly the vortical; the perpetual-vortical, properly the celestial;* and a highest, the perpetual-celestial, which is spiritual, and in which there is nothing but what is everlasting and infinite." There is then a scale of forms, whereof the higher are relatively more universal, more perfect, and more potent than the lower. The lower again involve the higher and the highest, and are generated by them: so that where there is an angular body, there is a circular form and force intimately present as its ground; where there is a circle, it is the limit of an interior spiral; and so forth. For nature operates from the very principles of geometry and mechanics, and converts them all to actuality and use. The purer substances in creation gyrate through the higher forms; the less pure circulate through the lower, or are fixed in the lowest. All the essentials of the angular form are opposed to each other, whence the origin of gravitating and inert matter, intrinsically unfitted for motion. But the other forms, according to their eminence, are more and more accommodated to motion and variation.

The Doctrine of Order teaches that those things which are superior in situation, are also superior in forces, in power, in dignity of office, and in use; and that a similar law determines the situation of the parts of things, and of the parts of parts.

* Swedenborg here uses the term celestial, not in the sense which is peculiar to it in his theological writings, but more with the meaning attached to it in the phrase, "celestial globe," as pertaining to the form of the universe.

Corresponding to the highest or first of the series of subordination, is the central or innermost of the series of coördination.

The Doctrine of Degrees teaches the distinct progressions through which nature passes when one thing is subordinated to, and coördinated with another. There are three discriminated degrees in all things, both natural and spiritual, corresponding to end, cause, and effect. In the human body there is a sphere of ends, a sphere of causes, and a sphere of effects. The body itself, comprehending the viscera of the abdomen and chest, and the external sensoria of the head, is the sphere of effects; the brain, and the whole of its appendages, are the sphere of causes; the cortical substances of the brain are the sphere of ends or principles. These spheres are subordinated to each other in just series from the highest to the lowest. The highest degree or sphere is active, the lowest is passive and reactive. The above degrees, in their order, indicate the progression from universals and singulars to generals or compounds. But every organ again involves the same triplicity of spheres; it consists of least parts, which are congregated into larger, and these into largest. All perfections ascend and descend according to degrees, and all attributes, functions, forces, modes, in a word, all accidents, follow their substances, and are similarly discriminated. Each degree is enveloped with its common covering, and communicates with those below it thereby. There is no continuous progression from a lower degree to a higher, but the unity of the lower is the compound of the higher, and in transcending that unity, we leap out of one series into another, in which all the predicates of force, form, perfection, &c., are changed and exalted. The Doctrine of Degrees enables us to obtain a distinct idea of the general principles of creation, and to observe the unity of plan that reigns throughout any given organic subject; and by shewing that all things are distinct representations of end, cause, and effect, it empowers the mind to refer variety to unity, as the effect to the cause, and the cause to the end, and to recognize the whole constitution of each series as homogeneous with its principles.

Series is the form under which the coördination and subor-

dination of things, according to order and degrees, ultimately present themselves. The whole body is a series, which may be looked at either generally, from above to below, as comprising the head, the chest, and the abdomen; or universally, from within to without, as divisible into the three spheres already alluded to. All the organs of each region are a series; each organ in itself is a series; and every part in each organ likewise. In short, everything is a series and in a series. There are both successive and simultaneous series, but the latter always arise from the former. Essences, attributes, accidents, and qualities, follow their substances in their series. Every series has its own first substance, which is more or less universal according as the series is more or less general. This first substance is its simple, unity, or least form, governing in the entire series, and by its gradual composition forming the whole. Each series has its limits, and ranges only from its minimum to its maximum. Whatever transcends those limits at either end, becomes part of another series. The compounds of all series represent their simples, and shew their form, nature, and mode of action. The Doctrine of Series and Society teaches that contiguity and continuity of structure, are indicative of relationship of function, and that what goes on in one part of a series, goes on also, with a determinable variety, in all the other parts: wherefore each organ is to be judged of, and analysed, by all the others that are above and around it. In this manner, the whole series is the means of shewing the function of each part of itself, and indeed of analysing that function into a series similar to that of the whole; for the least in every series must represent an idea of its universe. Under the operation of this law, the point becomes a world analogous to the great world, but infinitely more perfect, potent, and universal.

Such is a very brief illustration of the Doctrines of Order and Degrees, Series and Society, from which it will be evident how closely connected these doctrines are, and that they can hardly be stated without our seeming to repeat of one what has already been predicated of the others. Degrees appear to involve the distinct progressions of creation from above to below, or from within to without: order, to appertain to the

law of succession observed in degrees, whereby rank and height are given to excellence, priority, universality, and perfection; series, to involve the complex of the whole and the parts when created and coexisting; and society, to be the law of contiguity and relationship existing between different series, and between the parts of any single series. Perhaps it would not be far wrong to state in generals, that order and degrees involve the creating and successive, series and society, the created and simultaneous. But as we have said before, Swedenborg never stated these doctrines as promised in the "Animal Kingdom," but contented himself with using them as analytic instruments in the exploration of the body; and therefore the reader will learn them best in the way of example and illustration in the Work itself.

The Doctrine of Influx involves the manner in which the lower substances, forms and forces of the body subsist, as they at first existed, from the higher and the highest; and in which the body itself subsists from the soul, as it at first existed; and the natural world from the spiritual. But there is not only an influx from within, but also from without; and by virtue of both, the body, which otherwise would be a mere power, is raised into an active force.*

The Doctrine of Correspondence and Representation teaches that the natural sphere is the counterpart of the spiritual, and presents it as in a mirror; consequently that the forms and processes of the body are images of the forms and activities of the soul, and when seen in the right order, bring them forth and declare them. It shews that nature is the type of which the spiritual world is the ante-type, and therefore is the first school for instruction in the realities of that which is living and eternal.

The Doctrine of Modification teaches the laws of motion and change of state in the several auras or atmospheres of the world, and in their spiritual correspondents.†

What was stated of the Doctrines of Order, Degrees, Series, and Society, as mutually supposing, or as it were interpenetrating each other, may be repeated generally of the whole of

* See "Animal Kingdom," vol. II., p. 559.

† See ibid., vol. II., p. 49.

these doctrines, and this, because they are all but so many varied aspects of the one principle of divine truth or order. Like nature itself they are a series, each link of which involves all the others.

The Doctrine of Series and Degrees in conjunction with that of Correspondence and Representation, teaches that there is a universal analogy between all the spheres of creation, material, mental, and spiritual; and also between nature and all things in human society. The circulation of uses in the body perfectly represents the free intercourse of man with man, and the free interchange of commodities between nation and nation. The operations that go on in the body, analogically involve all the departments of human industry; nay, and infinitely more, both in subdivision, unity, and perfection. There is not an art or trade, whether high or low, so long as it be of good use, but the Creator himself has adopted and professed it in the human system. Nay, in the richness of his pervading love, the very prerogatives of the mind are representatively applicable to the body. End, cause, and effect, as existing in Himself, are represented in the latter as well as in the former. Liberty and rationality, the universal principles of humanity, are transplanted by analogy from the mind into the body. It presents an analogon of liberty, in that every organ, part, and particle, can successfully exercise an attraction for those fluids that are adapted to its life and uses; of rationality, in that it acts as though it took cognizance of the adaptability, and operates upon the materials demanded and supplied, in such a manner as will best secure the well-being of itself and of the whole system.

This may account to the reader for the extremely figurative character of Swedenborg's style, and shew that it proceeded from the reason and not from the imagination. It is because each thing is a centre to the life of all things, that each may freely use the exponent terms of all. Analogous uses in the body and the soul, furnish the point of contact between the two, and the possibility and the means of intercourse. Had Swedenborg confined himself to the dry straitness of what is now called science, he must have forfeited the end he had in view; for matter, as matter, has no communion with spirit,

nor death with life. It was absolutely necessary that the body should be tinctured with life in all possible ways, when it was to be the medium of instruction respecting the soul.

But it is time to instance a few of the results to which the above doctrines lead when wisely applied to the living body. It will, however, be impossible to give anything beyond the merest sketch of Swedenborg's physiology, or to look at it from more than a single point of view. He himself has regarded it from all sides, or from each organ and sphere of the body, and given what may be called a combined proof of its correctness.

The alimentary canal and the whole of the viscera of the abdomen form one grand series subservient to the creation of the blood. This again is divided into three inferior series, whereof one primarily respects the chyle, another the serum, and a third the blood already formed. There are then three series of digestions. 1. The alimentary canal commencing at the tongue and terminating with the rectum, performs as many distinct digestions of the food, and eliminates from it as many distinct products, as the canal itself has distinct divisions and articulations. Thus there is the chyle of the tongue and mouth, the chyle of the stomach, the chyle of the small intestines, and the chyle of the large intestines, and all these chyles subserve the blood in a successive series, coincide in its formation, and ultimately coexist within it in a simultaneous series. When the chyle has been inaugurated into the blood, and is once in the arteries and veins, it is no longer called chyle, but serum. 2. The serum is the object of the second digestion. The finer parts of it therefore are secreted, and the worthless parts are excreted and thrown out, just as was before the case with the food. The former operation is performed by the pancreas, the latter by the kidneys. 3. The blood itself is the object of the third digestion. This process, termed by Swedenborg the lustration of the blood, takes place in the capillaries and glandular elements all over the system, but specifically in the spleen, the pancreas, and the liver. As in the first series there are various menstrua or media between the chyle and the blood; namely, in the mouth, the saliva; in the stomach the gastric juice, which is the saliva potentialized by the peculiar action of the

stomach;* in the small intestines the pancreatic juice, and the hepatic and cystic biles; and in the large intestines the liquid distilled from the vermiform appendage of the cœcum; so in each of the other series corresponding menstrua are required and applied. The blood of the pancreas, and the blood of the spleen deprived of its serum by the pancreas, serve in the liver as a menstruum for refining the chyle and lustrating the blood. The lymph is a kind of ultimate saliva which digests the chyle as the common saliva digests the food. The lymph of the spleen, for instance, digests the chyle in the mesentery, as its blood digests the chyle and blood in the liver. In short, as all the abdominal viscera form one series of uses, so the lowest and largest form of that series may be taken as an exponent of the whole; and it will then be found that all these organs are high evolutions of the alimentary tube, digesting finer and finer aliments, (for the blood itself is the essential aliment of the body,) and throwing out subtler and subtler excrements or impurities. Thus the liver is the stomach of the chyle and blood; and the ductus hepaticus and the gall-bladder and ductus cysticus are respectively analogous in their proper series to the small and the large intestines.

The viscera of the thorax also minister to the blood. The heart is a chemical organ for preparing liquids to enter into its composition, at the same time that it is the beginning of the circulation. It separates the blood into two parts, a purer and a grosser; the purer it sends away through the lacunæ underneath the columns on its inner surface, by a series of ducts into the coronary vessels, which are the true veins of the heart;† the grosser into the lungs. Thus it also is an organ of blood-digestion or sanguification. The lungs have three general functions: 1. They lustrate all the blood of the body, especially in regard to its chyle or serum; their office in this respect being analogous to that of the kidneys in the abdomen. 2. They feed the blood with aërial and ethereal chyle, as the viscera of the abdomen with terrestrial chyle. 3. They call forth the powers of all the organs of the body by respiration. With re-

* See "Animal Kingdom," vol. I., p. 122, note (*a*); p. 133, note (*y*).

† On this subject, examine Swedenborg's "Economy of the Animal Kingdom," tr. i., n. 399—459.

spect to the last-named of these offices of the lungs, namely, that they supply the body and all its parts with motion, it is one of the most important discoveries in the "Animal Kingdom," and not less wonderful in its consequences than in its simplicity and obvious truth. If the reader can once succeed in apprehending it, there will be no danger of his letting it go again even among the perilous quicksands of modern experience. It is one of those truths that rest upon facts within the range of the most ordinary observation, and require but little anatomical investigation to confirm and demonstrate them. It is visible in its ultimate effects during every action that we perform, and at every moment of our lives. Perhaps there is nothing in the history of physical science that is more illustrative of the native ignorance of the mind, or that better shews how far we have departed from the simplicity of nature, than the manner in which this grand office of the lungs has been overlooked; particularly when coupled with the fact, that it should have required a great and peculiarly instructed genius, by an elaborate process, to place it once again under our mental vision. But nature is simple and easy; it is man that is difficult and perplexed. Not only in the lungs, but in the whole body, the primary office is disregarded, and the secondary substituted for it. It has been supposed that the lungs inspire simply to communicate certain elements of the air to the blood; and expire for no other end than to throw out by means of the returning air certain impurities from the blood. Under this view, their motion is only of use for other things, or instrumentally, and not as a thing in itself, or principally. And yet it is not confined to the sphere in which these secondary offices of the lungs are performed, but pervades the abdomen as sensibly as the chest, and according to the shewing of the experimentalists, extends also to the heart, the spinal marrow, and the head. It was therefore incumbent on the physiologist to shew what its function was in all the regions where it was present, and to declare its action as a universal cause, as well as its action as a particular cause. Now the motion itself which the lungs originate is their grand product to the system; the inspiration and expiration of the air are but one part of its necessary accompaniments, being performed in the chest alone.

Granting that the inspiration and expiration of the air are the particular use of this motion in the chest, what then is the use of the rising and falling which the lungs communicate to the abdomen, the heart, the spinal marrow, and the brain? What office, analogous to respiration, does the motion of these parts communicate to the organs? It manifestly causes them all to respire, or to attract the various materials of their uses, as the lungs attract the air. For respiration is predicable of the whole system as well as nutrition: otherwise the head would not be the head of the chest, nor the abdomen the abdomen of the chest; but the human body would be as disconnected, and as easily dissipated, as the systems that have been formed respecting it. The universal use, therefore, of the respiratory motion to the body, is, to rouse every organ to the performance of its functions by an external tractive force exerted upon its common membranes; and by causing the gentle expansion of the whole mass, to enable the organ, according to its particular fabric, situation, and connexion, to respire or attract such blood or fluid, and in such quantity, as its uses and wants require, and only such. Each organ, however, expands or contracts differently, according to the predicates just mentioned; the intestines, for instance, from articulation to articulation, to and fro; the kidneys, from their circumference to their sinuosity or hilus, and *vice versâ*, the neighborhood of their pelvis being their most quiet station and centre of motion: and so forth. In a word, the expansion as a force assumes the whole form of the structure of each organ. In all cases the motion is synchronous in times and moments with the respiration of the lungs. The fluids in the organs follow the path of the expansion and contraction, and tend to the centre of motion, from which these motions begin, to which they return, and in which they terminate. The lungs, however, only supply the external moving life of the body; but were it not for them, the whole organism would simply exist in potency, or more properly speaking, would cease to be; or were it permeated by the blood of the heart,—a condition which can by no means be granted,—the latter would rule uncontrolled in all the members, subjugate their individualities, and not excite them to exercise any of the peculiar forces of which they are the forms. In a word, the whole man

would be permanently in the fœtal state, for ever inchoate and ineffective.

It need not surprise the members of the New Church that no writer before or since the time of Swedenborg should have seen the primary function of the lungs in the human body. For it is shewn in those wonderful theological treatises with which they are familiar, that the heart and lungs of the natural body correspond to the will and understanding of the spiritual man; and as the understanding or rational mind has hitherto brought out none of those truths which enable man spiritually to live, nor been an external cause coöperating with the Word as an internal cause in the work of regeneration, so it had in itself no ground from which to recognise the necessity of the above function in the human frame; but its lower chambers alone being opened, took cognizance only of the lower and relatively passive offices of its bodily correspondent, the lungs. Unwittingly it yielded up the sceptre of the body to the heart, and here again obeyed the law of correspondence. But the truth is that the lungs mediate between the brain and the body, precisely as the rational mind of man is intended to mediate between heaven and earth.

The brain supplies the body and the blood with life, and its functions in this respect combine nutrition, circulation, and respiration. It respires the ethers of the world, it nourishes its life with ethereal chyle, and it circulates the animal spirit elaborated therefrom through the corporeal system. It may be regarded as a unity which involves in principle and idea all the varieties that are manifested in the two inferior regions of the thorax and abdomen. Its cortical substances involve the functions of both the heart and lungs, because they are in the degree above both. They are so many corcula propelling the animal spirit through the medullary fibres and nervous system, and so many pulmuncula performing an animatory motion synchronous with the respiratory motion of the lungs, although not dependent upon it, but automatic or self-derived, and which indeed generates the motion of the lungs, as the end generates the cause, or the cause the effect. The ethereal medium that they respire they derive principally through what are termed by Swedenborg the corporeal fibres, which originate in the skin,

and run back from the last boundaries of the body to the first in the brain. Now the physiologists have never discovered the animation of the brain, because they have never seen the respiration of the lungs in its primary light. Had they done this, it would have been evident that the respiratory motion exercises a traction upon the sheaths of all the great nerves, and expands them, and that this traction is the external cause of a nervous circulation; for were there no fluid to respond to the force, there would be a tendency to a vacuum in these most impressible organs, and their parts would be strained, or drawn asunder. But if there be a real circulation in the nervous system, it must have centres that propel it, and times and moments in which it is performed. We have already seen that in this case the fluid is externally drawn forth by the attraction of the lungs, consequently in the times of the respirations, and hence it must be drawn in by the brains in the same times; in short, the animations of the brains must be synchronous with the respirations of the lungs. Hence it is that the brain supplies the body with internal motive force at the same instants as do the lungs with external; the heart only maintaining the organs in a state of potency, and supplying what they demand by the influx of this compound attractive force operating according to their various fabrics.

It must not be inferred that a truth of such paramount importance in physiology as the animation of the brain, rests upon the slight chain of reasoning attempted above. No; its attestation is as general as the truth itself is universal. But since Swedenborg has taken the proof of it upon his own Atlantean shoulders, the reader is referred to his treatise* on the subject for further corroborations. But it may be useful to indicate, that the doctrine is in no way shaken by the existence of the pulsatile movement so readily felt in young children, nor yet of that other movement, alternate and not synchronous with the respirations, which has been observed by some experimentalists. The truth is that all the three movements proceed uninterrupted by each other; and that the alternate movement, which is referable to the blood rushing out by the veins during inspiration, is

* Economy of the Animal Kingdom, tr: ii., 1—68.

what chiefly masks the synchronous movement, which is automatic, or referable to the brain itself.

There is no part of Swedenborg's system which is better worthy of attention than the doctrine of the skin. As the skin is the continent and ultimate of the whole system, so all the forms, forces and uses of the interior parts coexist within it. Moreover as it is the extreme of the body, and the contact of extremes, or circulation, is a perpetual law of nature, so from the skin a return is made to the other extreme, namely, to the cortical substances of the brain. Hence the first function of the skin is, "to serve as a new source of fibres." For the fibres of one extreme, to wit, the brain, also called by Swedenborg the fibres of the soul, could not of themselves complete the formation of the body, but could only supply its active grounds; and therefore these fibres proceed outwards to the skin, which is the most general sensorial expanse of the brain, and there generate the papillæ; and again emerging from the papillæ, and convoluted into a minute canal or pore, they take a new nature and name from their new beginning, and become the corporeal fibres, or the fibres of the body, which proceed from without inwards to the brain, and unite themselves to its cortical substances. These are the passives of which the nervous fibres are the actives; the veins or female forces of which the nervous fibres are the arteries or males; and "they suck in the purer elemental food from the air and ether, convey it to their terminations, and expend it upon the uses of life."

Besides this, the skin has a series of other functions which there is not space to dwell upon at present. Inasmuch as it is the most general covering of the body, therefore it communicates by a wonderful continuity with all the particular coverings of the viscera and organs, and of their parts, and parts of parts. And as it communicates with all by continuity of structure, so it also communicates by continuity of function; the whole body being therefore one grand sensorium of the sense of touch. In short, the animal spirit is the most universal and singular essence of the body and all its parts; the skin, the most general and particular form corresponding to that essence.

Having thus bestowed a cursory glance upon some points of Swedenborg's doctrine of the three spheres of the body, and

their most general and particular continent, the skin, we shall now enlarge a little on certain subjects that have already been mentioned, in order to give them a more distinct place in the reader's apprehension. And first with respect to the circulation. It is clear that in assigning its due weight to the primary function of the lungs, we obtain a law which enables us to limit the functions of the heart and arteries; and the result is, that the heart and aorta simply propel the blood to the mouths of the arteries leading into the viscera, and the viscera themselves attract it thenceforth, and dominate over the circulation of their own vessels, commanding it to take place in the times of the respirations, and not in the times of the pulses of the heart. As one means to this end, the vessels which supply the organs, generally come off at right angles from the great artery.

But there is another branch of this subject which is worthy of attention. The circulation in the great vessels is comparatively inordinate or confused, because in them the blood is all mingled together in a heterogeneous mass, and propelled onwards by an external force; but the circulation in the capillaries is most orderly and distinct, being an automatic movement performed by the single globules of the blood, in vessels which correspond to them individually, and where they are perfectly at home. If a comparison be permitted, they constitute a medley crowd in the heart and aorta, but march separately, man by man, in the capillaries. Hence the blood in its mass can but imperfectly manifest its living endowments, but when sundered into its individualities or leasts, it distinctly exercises its dynamic nature, and flows spontaneously; for it is a spiral and circular force, and tends therefore to a spiral gyration, or to circulation. Indeed in a universal sense, the leasts of the blood are the causes of the heart's action, and the grounds of the whole sanguineous movement; although speaking in generals, the heart, and the lungs acting on the viscera, are the joint causes of this effect.

The blood is the product of the whole organic system. The brain and lungs give it soul and spirit; the abdominal viscera, by means of the food, supply it with body or embodiment; wherefore each globule is an image of man inasmuch as it has both a soul and a body. Every viscus contributes a distinct

share to its generation and regeneration. The animal spirit is its organizing principle. The blood consists, in the language of Swedenborg, of mere simples; that is to say, it contains the primal unities of all the series in the body, and being readily resolvable into each, can give origin and seed to all its possible compounds, whether they be solids or fluids. Nothing exists in the body that did not preëxist in the blood. As it is distinctly compounded of a triple order of substances, so during each round of the circulation it is distinctly decompounded or resolved into each. Its spirit, spirituous lymph, and bodily portion are sundered as often as it circulates; the former is claimed by the cortical substances of the brain; the lymph is rendered back to the blood in a circle by the lymphatics; and the embodiment, by the veins. The reason why it undergoes this resolution is, that thereby, when its simples are disengaged, it gives birth to all the vital fluids, and renovates all the solids; and moreover submits itself to perpetual purification, self-examination, or lustration. Those portions of it which are no longer of use are thrown out of the system by various excretions, the loss thus occasioned producing that sense in the little veins all over the body, which in the aggregate we term hunger and thirst. The blood of the jugular veins which has been de-spirituated in the brain, is vivified afresh in the lateral sinuses, by a spirituous lymph sent forth from the pituitary gland, which is the conglobate gland of the cerebrum. Thus the effete spirit of the brain unites with its effete blood, and both together serve as a menstruum, medium, or saliva for introducing the new chyle into the sanguineous system. It is for this reason that the thoracic duct is inserted at or near the bottom of the jugular vein. But the circulation of the blood, although it may be considered by itself, yet like all things in the body, is but a part of a more universal order, termed by our author the circle of life; and which involves in one the circulation of both the blood and the spirits.

All the fluids of the body institute circulations after the image of the circulation of the blood. Such may be readily seen to be the case with respect to the saliva, the bile, the fat, &c., &c.

The circulation of the animal spirits, supplied to the brain

through the corporeal fibres from the ethereal media of the universe, as well as by the blood of the carotid arteries, and elaborated in the cortical substances, is not a simple circle, like that of the blood, but a transcendent circle, leaping from series to series, omnipresent in all things and conjoining all. For the spirit is propelled by the cortical substances or "corcula cerebri" through the medullary and nervous fibres; by the nervous fibres into the arteries, where it is inserted into the globules of the blood, and constitutes their life and soul; and it is carried back in the blood by the carotid arteries to the same cortical substances, there to be purified, conjoined with fresh spirit, and begin its circle anew. The animation of the brain is the first moving cause of the circulation of the spirits; the respiration of the lungs the secondary or corporeal cause, which operates by a general traction upon the external membranes of all the organs, vessels, and fibres of the body. For the brains give the universal or most internal life of the body, and in this respect, as propulsive causes, represent the capillaries or distinct corcula of the nervous circulation; the lungs, the general, or most external life, and represent the one heart of the same.

The above doctrine may conveniently suggest the idea, that points of analogy are not points of sameness or identity, but in reality, of harmonic difference. The circulation of the blood is one thing, and images that of the spirits; but notwithstanding, the circulation of the spirits is quite another. Each fluid has its own peculiarities, and its circle is applicable only to its own sphere. It is an abuse of analogy if we use it to destroy and not to reconcile differences; and if so abused, it becomes a childish and paltry instrument, totally inadequate to guide the mind through the labyrinths of nature. To revert to the present case, it has been attempted to be shewn, that the circulation of the animal spirits is a simple circle, precisely like that of the blood. But for the purposes of analysis, it ought to be paralleled with what is higher than itself, and not with what is lower. Let us take as illustrative the grand circle involved in generation; for "all things that involve an end constitute a circle." In this example, the male and female conspire to generate a new being: the male fluid is propelled out of the body into the body of the female, or from one series into another; here it is

developed or embodied, and is again propelled from the maternal series into that of the external universe: afterwards it is developed inwards from the body to the mind, and when its circles of education and information are completed, it returns as a member of that society from which it proceeded, to commune with the principles that gave it origin in the parents, to amplify their sphere, and enlarge their amount of social life. The circulation of the spirits is more like this of generation, than like that of the blood; for being a universal it belongs to the sphere of universals, and is but poorly imaged in particulars, which are, indeed, but portions of itself.

We have already treated of the limits of the circulation considered as proceeding from the heart, and have had occasion to hint at the attraction exercised by the several organs. The truth is, that the latter demand different and varying quantities and qualities of blood at different times, according to their different states as determined by and determining the state of the body; and that the heart and aorta, as a propulsive power, can have no share in apportioning these. Hence an attractive force is given to the viscera themselves, whereby all the commodities in the body are placed at their disposal; or as Swedenborg says, "they are enabled to summon what they require, from the universal mass of the blood." For each organ, and each part and particle of each, is an individual member of a perfect society, possessing the form of a stupendous rationality whereby to discern its wants, and of an equal liberty to enable it to supply those wants from the community, on the condition of reciprocation of use: not the smallest intrusion upon its individuality by the common powers is permitted for a moment; for should this take place, disease is the inevitable consequence. But let it not be imagined that the attraction exerted by the organs is of a violent character, or that their movements are other than gentle and tranquil. It is unnecessary that such should be the case; inasmuch as there is always a propulsion or incitation corresponding to the attraction or invitation, so that what the organ demands is immediately supplied. For when the unities or leasts of an organ expand to draw in their blood, their vessels contract to propel it; and by virtue of the simultaneous expansion of the unities and contraction of the vessels, the size of

the organ is scarcely altered, and its motion is almost imperceptible.

The motions of the organs of the body are an important subject in Swedenborg's theory; occasionally seen in glimpses by many writers, among whom may be instanced our own philosophic Glisson,* yet not recognized by them as a necessary law. It has been remarked before, that the lungs and the brains give each organ a universal motion, at once internal and external. But it would be an error to suppose, because the motion communicated is one and the same, that therefore it is not received and appropriated differently, in other words, modified, by the organs themselves. So truly is this the case, that the motion takes place in every instance in accordance with the geometrical form of the organ, as made up of lesser and least parts, and these forming axes, diameters, and circumferences, general, specific, particular, and singular. Always indeed it is expansion and constriction, these being nature's own motions, and pervading the universe, elemental, material, and organic. Nevertheless it is an expansion and constriction proceeding according to the form of the organ. As a general rule, the most fixed point of every organ is its centre of motion, from which its expansion and constriction begins, to which it returns, and in which it terminates. For each organ is an individual, made up of an infinity of lesser individuals, whereof one and all live their own lives, exercise their own forces, and perform their own actions, and only rely upon the general system for supplies, which they can convert to use in their own way, and according to their own essence; and this, no matter whether the supplies be supplies of blood and fluids, or supplies of motion. The material always comes from without, but the disposal of it from within. These motions convert the organs from powers into forces; so that it may be stated as a law, that the heart and the blood generate the body; but that the brain and the lungs make use of it, and wield it as an instrument of action. As a rude illustration of this, we may instance the case of human machines. The fabrication of a steam engine by artificers in the workshop is one thing, and analogous to the formation of the

* Glisson is well worth consulting on the motion of the liver: see his "Anatomia Hepatis," pp. 62, 63, 67, 68, 69; 12mo., Amsterdam, 1659.

body by the blood, the vessels, and the heart; but to make use of the same engine requires altogether a different series of powers,—fire, water, steam, and a new order of workmen, analogous to the brain, the lungs, and their motions.

As motion is a necessary condition of actual life in the whole body, and all its organs and their parts, so likewise is sensation. For without sensation the organs would not be able to exercise their attractions and repulsions with benefit either to themselves or the system. The cerebrum is our general sensorium, in which we are conscious of all the impressions that rise from the external sensoria, of sight, hearing, smell, taste, and touch; which sensoria occupy the circumference of the body: but the cerebellum takes cognizance, apart from our consciousness, of all the impressions that are made in the interiors of the body; namely, of every contact,* in general and in particular, between the solids and the fluids. Therefore the cerebellum is aware of the whole state of the kingdom of the body in its minutest details, and disposes and governs it agreeably to the ends for which corporeal life is instituted. Now the human frame, unlike that of other animals, is coördinate with the *whole* external universe; it is an organization correlated and responsive to the entire series of the natural creation. The brain is a form of the elemental kingdom; the lungs, of the atmospheric world; and the abdomen, of the terraqueous globe. Nothing less than this can be the case, inasmuch as the body descends from the highest sphere to the lowest, and, by the heart and its vessels, reascends from the lowest to the highest, and thus doubly draws with it the order of the universe. Each degree of the body involves a sensation of its external coördinate. Of the external senses specifically, sight is coördinate with the ether, and apprehends its modifications; hearing, with the air, and perceives its vibrations; smell, with the effluvia of matter; taste, with the essences of body; and touch, with body in its ultimate or concrete form. The first two senses therefore are

* It is suggested to the medical reader to consider, whether Swedenborg's theory, that the sense of touch, and its organism and accidents, pervade every particle of the body, lends any support to the remarkable view taken by Hahnemann, that seven eighths of the chronic maladies afflicting the human frame are forms of psora, and that *all* such maladies are referable in some sense to three types of skin disease.

atmospheric senses; the latter, material, and may be fitly regarded as different forms of touch. There are then three grand genera of touch. The first genus prevails all over the circumference, and constitutes touch proper: the second prevails in the innermost parts of the body, beginning from the tongue; namely, in the œsophagus, the stomach, the intestines, and all the viscera of the abdomen, and at the threshold of this series is called taste: the third genus prevails likewise in the innermost parts of the body, but beginning from the nares; namely, in the trachea, the larynx, and the lungs, or in the viscera of the thorax, and at the entrance to these is called smell. The sense of taste again is divided into as many species as there are viscera of the abdomen, and these species into as many particular differences as there are unities in each viscus. "From the variety of the particular sensations of one viscus, a common sensation arises; and from the variety of sensations of many viscera, a still more common sensation arises. And from all and each of these sensations conveyed by the fibres to the cerebellum, the soul, by means of this sense, here apperceives specifically the states of chylification, sanguification, and purification; in a word, of nutrition; and according to the perception, disposes those viscera to the conservation of the whole and the parts, which is the effect and use that this sense produces." The villi on the internal surfaces of the abdominal organs are the papillary sensoria of the above sense.

Thus in the living body sense and motion are universal, and mutually suppose each other, just as is the case in the mind with the will and the understanding. The deprivation of any one of these predicates in any part of its own sphere, amounts to the death of that part, and either involves its elimination, or the death of the whole system.

But as every part of the body is a free individual, dependent upon the whole, and yet independent in its own sphere, so the body itself, although sustained generally by the external universe, in its interiors is altogether exempt from the power and jurisdiction of the latter. It is so far under the mundane law of gravitation, that we are forced to make our dwelling-place, build up our abodes, and institute our communities, upon the soil of the earth: but intrinsically the microcosm dominates

over the macrocosm. The substances and fluids in its interiors do in fact gravitate, although not to the centre of the planet, but to that of the particular motion in whose current they are involved. This centre of motion may be either upward or downward, speaking according to those relations as existing in the surrounding world; for in the body the centre of motion is always the downward point, and its diameters and circumferences are always the upward; for the body itself is nothing but a stupendous series of motions, in whose everlasting currents its solids are ranged and its fluids are fluent. When any substance has attained one centre of motion, it is then at rest in the viscus or organ in whose sphere it was moving: but that very centre is only a point in the circumference of another sphere, to the centre of which the substance is now again drawn and impelled; and so forth. In short, all things in the bodily system are tending from centre to centre, and do not begin to tend to the centre of the planet, until they arrive in the last, lowest, and most general centre of motion of the microcosm, where a mixed action commences between it and the macrocosm, as is the case in the bladder and the rectum. In illustration of this multiple centripetency, the fluids in the gyrating intestines tend first to their parietes, and then into their cellular coat, which is their centre of motion: this centre of motion is the circumference of the mesentery, which now, by its attraction, draws the fluids to its most quiet station or centre of motion, namely, to the receptaculum chyli. Here again, in reasoning from the external world to the internal, we may see the use of cultivating in the mind a principle of flexibility, which will enable us to modulate from the order of one sphere into that of another; for each individual subject has its own essence and peculiarities which must never be overlooked, and although formed on the model of the universe, derives its determinations from its own principles, as much as the universe does from its own principles. All things are under the law of gravitation, but the gravitation of one is not the gravitation of another, because the motion is not the same, nor the end for which the motion is instituted.

Thus in the body we have a perpetual illustration of the law, that fluids always tend from unquiet to more quiet sta-

tions; analogous to the rule in physics, that fluids always find their level; and to the principle in the spiritual world, that every man gravitates, "per varios casus, per tot discrimina rerum," to the final state of his ruling love.

This may give us some idea of the body as a machine of ends, in which there is not the least point but flows from a use, and tends to a use, and so through perpetual revolutions. For every part of the organism is a centre in itself, in that the whole body conspires to supply and maintain it; and a circumference, since being only a part, it yields its uses primarily to the whole, and only secondarily to itself. The external universe, in all its spheres, communicates with the body by a similar law. These centres, arranged according to the laws of forms, order, degrees, and series, constitute diameters and circumferences, in a word, make up the human frame, which therefore is a world of centres, or speaking generally, is the central work of creation. For there is nothing in nature but man, to which all things can minister a use.

The body is exempt not only from the gravitation but from the chemistry of the circumambient world. It has its own heat, of which there are various degrees, and which is as distinct from the heat that vivifies external nature, as its gravitation is distinct from the gravitation of nature. It has its own distinct imponderable fluids, its own atmospheric elements, its own fluids, and its own solids. It has its own complete organic chemistry, in which organization is the only end. No chemical changes that occur in the extremes of the system, (where a mixed action commences, of the microcosm and the macrocosm,) no chemical analysis of the excrements or the excretions, no experiments on the dead fluids or tissues, empowers us in the slightest degree to reason to similar chemical effects in the interiors of the body. The organs of the body themselves are the only workmen, appliances, and laboratories, by which and in which organic chemistry is performed; the contemplation of those organs and their products by the rational mind is the only path to the knowledge of such chemistry. In this chemistry there is indeed decomposition or decombination, but instead of a destruction of form and series, a purification from those elements that mar their harmony, and in the decombina-

tion, an evolution of higher forces, and an elevation into a more perfect order similar to that of the compound; and last of all, invariably a recombination. But to take a part or product of an organic being, and subject it to destructive analysis, —such a procedure can only be termed disorganic chemistry, as expressing that it is the very reverse of what goes on in the body. For this process is analogous to putrefaction, and not to formation.

Throughout nature every general is made up of its own particulars. These particulars are its unities, and constitute the limits of its series. For instance, the pulmonary vesicles are the unities of the lungs, or the essential parts from which the pulmonary series commences: the vessels and nerves that construct these vesicles are not the unities of the lungs, because they are not peculiar to the lungs, but form the groundwork of the whole body. Men and women are the unities or atoms of human society, not that they are indivisible, but that they are the simplest forms of their own series. The unities of each organ in the body are so many little organs homogeneous with their compound: the unities of the tongue are little tongues; those of the stomach are little stomachs; those of the liver are little livers; and so forth. These leasts or unities are not necessarily identical with their compounds in form, but only in function; for in the field of leasts (in campo minimorum), similitude of use determines homogeneity, and similitude of shape is of no consequence. As every general is the sum of its particulars as a form, so is it also as a power, force or cause. The function represented by an organ is performed more freely, perfectly, and efficiently, by its unities or leasts, than by its common form. For the leasts are the subjects of higher influences, they are more proximately related to the series above them from which the power of the whole is derived, more easily exempted from the laws of gravity, and more gently and distinctly recipient of external forces. They are nearer to the substance of substances, and as it were more divine. They are the all in all of their own series; the essences of which the general is the form; the actives of which the compound is the passive. In the expressive language of Swedenborg, "all power resides in the least things," and again, "nature is great-

est in what is least, and least in what is greatest."* The field of leasts is the field of universality, where an action communicated pervades the entire sphere as though it were but a point of space; for the more internal the sphere, the more intense the association. The stream of creative influx enters the compound through the gate of its leasts. The difference between the latter and the former is as between the ideal and the real; the ideal being represented in the leasts; the real, with its complications, and subservience to secondary laws and external circumstances, in the compound. Let us recur for an example to the highest and simplest instance; to the case as existing between an individual man, and a society or a nation. In the individual, the body is the very manifestation of the mind; the servant is the obedient and accurate image of the master. The will, as the ground of activity, flows through a series of intellectual means evoked from itself, with the smallest diminution of force and efficiency into the bodily actions, there being no separate or self interest to absorb it either in the understanding or the body; and thus the monarchy of the first principle is pervading, absolute, and complete. But how different are the actions of a society or compound individual; its interests how divided; its instruments how insubordinate; how great the distance between its legislative and executive, its will and its actions; through what inept mediations the former must pass into the latter; what an absorption is there of the first force in the passage; what a refraction and dispersion of the intentions of the government before they can ultimately be applied to the governed. Now the same is true with the simples and compounds of every series in creation, as with the simples and compounds of humanity.

We come now to speak of the formation of the body, which takes place by a gradual descent from the higher to the lower forms, or by the perpetual derivation, composition, and convolution of simples. Speaking in generals, the spiral form may illustrate the progression. For this purpose let us assume the primary fibre of the brain, without going deeper, or to the spherules of which that first fibre is composed. This fibre,

* Principia, Part I., Chap. x., § 8.

named by Swedenborg the fibre of the soul, involves the spiral form and force, and carries the animal spirit. By its evolution, or what amounts to the same thing, its circumvolution into a new spiral, it forms the nervous fibre, which carries the true purer blood, or nervous fluid; and this again (for it likewise is a spiral force), by its circumvolution generates the blood-vessel, which carries the fluid of the third degree or sphere, namely, the red blood. Hence every artery involves a triple series of circulations, wonderfully alternating with each other. For the nervous fibre, in its expansion and constriction, is precisely alternate with, or the inverse of, the primary fibre; and the same relation of harmonious discord subsists again between the blood-vessel and the nervous fibre. Thus the cause of expansion in the one sphere, is the cause of constriction in the sphere above it: to convert the expansion of the blood-vessels into constriction, the nerves are approached by an expansile agent adapted to their own subtle and active nature; for by the law of inversion, the expansion of the one = the constriction of the other. The play of this inversion, in its perfect form, is a condition of health; but in man's present state, the equilibrium is too often lost, there being, in the words of Swedenborg, "a perpetual battle and collision between the three spheres of the body, namely, between the blood and the spirits, and between the spirits and the soul."

The last subject on which it will be necessary to say a few words in this department of our remarks, is the distinction between the life before birth, and the life after birth. In the fœtus, nature, that is to say, the soul, as an end and formative power, alone rules, and all things proceed in natural order, from the highest or innermost sphere to the lowest or outermost, by the synthetic way, or *a priori ad posteriora*. But after birth, the will rules over nature, and drives her from her throne, and all operations proceed in inverse order, by the analytic way, or *a posteriori ad priora*. These opposite states require a medium to reconcile between them, which medium is supplied by the opening of the lungs; the animations of the brains being synchronous with the respirations after birth, but with the pulsations of the heart during uterine life. In the fœtus, the higher spheres act, and the lower react; whereas after birth

the lower act, and the higher only react. In the former case all operations are universal and most individual, conspiring by intrinsic harmony, and in perfect freedom, and proceed outwards from the brains; in the latter they are in the first place general, and proceed inwards to the sphere of particulars through the coverings, membranes, or bonds, of the body and its organs. But the reader will not acquire a satisfactory understanding of this wonderful doctrine by anything short of an attentive study of Swedenborg himself.

There are certain organs in the body which have always been looked upon as the *opprobria* of physiologists, who indeed appear to fail wherever nature does not speak by an ultimate fact; that is to say, wherever there is a clear field for the understanding as apart from and above the senses. The absence of an excretory duct is sufficient to consign an organ in perpetuity to the limbo of doubt. Surmise indeed respecting its functions is still allowed, but proof is considered impossible. We might as well pretend to know the nature of the world of spirits as to know the function of the spleen. We should be as rank visionaries in the one case as in the other, since we should be placing an implicit dependence upon reason, in a matter where the bodily senses give no direct information. Swedenborg did pretend to know both, and ill he fared in consequence with the scientific world, and with the first reviewer of his "Animal Kingdom" in the "Acta Eruditorum Lipsiensia." They said he was "a happy fellow," and laughed outright. Without stopping to do more than direct the reader's particular attention to his doctrine of the spleen, the suprarenal capsules, and the thymus gland, as being satisfactory and irrefragable, it may be wondered why the physiologists should single out those organs as especial subjects whereon to make confession of ignorance. There is modesty in their confession, but it ought in justice to have embraced more. These organs are closely connected to others, and ignorance respecting them involves ignorance respecting the others also. Connexion of structures in the body is also connexion of functions, forces, modes, and accidents. If the function of the spleen be unknown, so precisely to the same extent are the functions of the pancreas, the stomach, the omentum, and the liver; if the functions of the succenturiate

kidneys be unknown, so are the functions of the diaphragm, the kidneys, the peritonæum, and indeed of the whole body; for the body is a continuous tissue, woven without a break in nature's loom. To be ignorant of a part, is to be ignorant of something that pervades the whole. The disease that affects the spleen, affects the whole, for the spleen is in all things, and all things are in the spleen. To recur to the liver: what is the amount of knowledge respecting its functions? Precisely this, that the hepatic duct proceeds from it, and carries bile into the duodenum. The bile and the duct are the sum and substance of the modern physiology of the liver; it is *prorsus in occulto* why either bile or duct should exist. The truth then is, that there is as much known about the liver as about the spleen, and no more; in the one case it is known that there is an excretory duct, in the other that there is none. Alas! the scientific mind is steeped in the senses, and is the drudge of their limited sphere.

Swedenborg's analysis is professedly supported upon the foundation of the old anatomists, who flourished in the Augustan age of the science. At his time nearly all the great and certain facts of anatomy were already known; such for example as the circulation of the blood, and the existence of the lymphatics and the lacteals. Anatomy, too, had long been cultivated distinctly in the human subject, and was to a great extent purified of the errors that crept into it at first from the habit of dissecting the lower animals. Many of the old anatomists were men of a philosophic spirit, who proposed to themselves the problem of the universe, and solved it in their own way, or tried to solve it. They were the first observers of nature's speaking marvels in the organic sphere, and described them with feelings of delight, which shewed that they were receptive of instruction from the great fountain of truth. They worked at once with the mind and the senses in the field of observation. There was a certain superior manner and artistic form in their treatises. They believed instinctively in the doctrine of use. They expected nature to be wonderful, and supposed therefore that the human body involved much which it required the distinct exercise of the mind to discover. Hence their belief in the existence of the animal spirits; a belief which they based

upon common sense, or what amounts to the same thing, upon the general experience of effects; at the same time that they recognized its object as beyond sensual experience, and not to be confirmed directly by sight.* They used the microscope to assist and fortify the eye, and not to substitute it, or dissipate its objective sphere. Even the greatest among them, who addicted himself to the bare study of structure and the making of illustrative preparations, expressed a noble hope that others would complete his labors, by making as distinct a study of uses.†

But the picture is not without its darker side. Although they had strong instincts and vivid glimpses of truth, yet when they attempted to carry their perceptions out, they degenerated into mere hypotheses, and systems of hypotheses. They did not ascend high enough before they again descended, nor did they explore nature by an integral method; and hence they had no means of pursuing analogies without destroying the everlasting distinctions of things. They stopped in that midway where scepticism easily overtook them, and where, when that enemy of the human intellect had once penetrated, there was no possibility of maintaining themselves, but the fall to the sensual sphere was inevitable. The reason of this was, that they had not conceived the laws of order, and therefore could not claim the support which nature gives to all her truths. Nay, it was so impossible that they should proceed further without the tincture of a universal method, that their minds came to a standstill; the truths already elicited were rendered unsatisfactory, and mere progress demanded their fall. They fell therefore, and a race which knows them not is dwelling now in tent and hut among their mighty ruins.

At the very crisis of their fate, Swedenborg took the field for the end that has been already mentioned, and at once declared, that unless matters were carried higher, experimental knowledge itself would perish, and the arts and sciences be carried to the tomb, adding that he was much mistaken if the world's destinies were not tending thitherwards. The task that he undertook was, to build the heaps of experience into

* See Heister. † Ruysch.

a palace in which the human mind might dwell, and enjoy security from without, and spiritual prosperity from within. He brought to that task requisites, both external and internal, of an extraordinary kind. He was a naturalized subject in all the kingdoms of human thought, and yet was born at the same time to another order and a better country. To the various classes of schoolmen he appears never to have attached himself, excepting for different purposes from theirs. He pursued mathematics for a distinctly extraneous end. As a student of physiology he belonged to no clique or school, and had no class-prejudices to encounter. In theology he was almost as free mentally, as though not a single commentator had written, or system been formed, but as though his hands were the first in which the Word of God was placed in its virgin purity. Add to this that he by no means disregarded the works of others, but was learned in all useful learning. He had a sound practical education, and was employed daily in the actual business of life for a series of years. He was thoroughly acquainted with mechanics, chemistry, mathematics, astronomy, and the other sciences as known in his time, and had elicited universal truths in the sphere of each. From the beginning he perceived that there was an order in nature. This enabled him to pursue his own studies with a view to order. He ascended from the theory of earthy substances to the theory of the atmospheres, and from both to the theory of cosmogony, and came gradually to man as the crowning object of nature. He brought the order of the macrocosm to illustrate the order of the microcosm. His dominant end, which he never lost sight of for a moment, was spiritual and moral, which preserved his mind alive in a long course of physical studies, and empowered him to see life and substance in the otherwise dead machinery of the creation. He was a man of uncommon humbleness, and never once looked back, to gratify self-complacency, upon past achievements, but travelled onwards and still onwards, "without fatigue and without repose," to a home in the fruition of the infinite and eternal. Such was the competitor who now entered the arena of what had, until this time, been exclusively medical science; truly a man of whom it is not too much to say, that he possessed the kindliest, broadest, highest, most theoretical and most prac-

tical genius that it has yet pleased God to bestow on the weary ages of civilization.

Swedenborg perceived that the permanence of nature depends upon the excellence of its order; that all creation exists and subsists as one thing from God; that divine love is its end; divine wisdom, its cause; and divine order, in the theatre of use, the simultaneous or ultimate form of that wisdom and love. He also perceived, that the permanence of any human system, whether a philosophy or a society, depends upon the coincidence between its order and the order of creation; and that when this coincidence exists, the perceptions of reason have a fixed place and habitation on the earth, from which it will be impossible to dislodge them by anything short of a crumbling down of all the faculties, both rational and sensual; a result which, if the human heart be improving, the belief in a God forbids us to anticipate. But Swedenborg did not rest, as the philosophers do, in a mere algebraical perception of the truth, or in recognizing a want without supplying it; but like a good and faithful servant he actually expounded a system of principles at one with nature herself, and which will attest their order and their real Author by standing for ages of ages.

But his still small voice commanded no attention, and what he predicted took place: the sciences *were* carried to the tomb, where they are now buried, with the mind their subject, in the small dust of modern experience. This brings us to say a few words of the physiology of the day.

Facts are the grand quest of the present time, and these, particular facts: general facts are less recognized now than they were at the beginning of the last century; for short-sightedness has so increased upon us, that we must look close in order to see distinctly, and hence extended surfaces do not fall under our vision. The physiologist defers reasoning until the accumulation of facts is sufficiently great, to suggest reasons out of its own bosom. This is a step beyond ordinary materialism. The individual materialist considers that matter must be organized into the form of a brain before it can think and will; but that compound materialist, the scientific world, expects dead matter to open its mouth and utter wisdom, without any such previous process. It thinks that at present there is not

matter enough, or this result would ensue; little dreaming that there is a fault in itself, and that the larger the stores it possesses, the more impossible it will be to evolve their principles, or to marshal them under a theory. The common facts of the body having been pretty well explored, the physiologists go inwards, and gather further facts. Without waiting to ascertain the import of these, they submit them to the microscope, and again decompose them; and so on, to the limits prescribed by nature to the optician, and by the optician to the scientific enquirer. But is the field of leasts more easy to discern than that of compounds; or if we cannot read nature's secret in her countenance, can we expect to divine it from her very brains? The truth is, that the modern state of physiology is a universal dispersion of even sensual knowledge: its pretended respect for facts is not real; otherwise it would enquire into their general significance before resolving them into further elements. It perpetually illustrates the principle that facts cannot be duly respected unless they are seen as agents of uses, and results of ends and causes; and that if they are not so regarded, they become mere playthings, to which novelty itself can lend scarcely a momentary charm.

But as every end progresses through more means than one, so science is undergoing dispersion in another direction also. Not only are the generals of anatomy forgotten for its particulars, but the human frame itself is in a great measure deserted for comparative anatomy. The so-called human physiologist pursues his diffuse circle from animal to animal, from insect to insect, and from plant to plant. Man is confounded with the lower and lowest things, as if all the spheres of creation were in one plane of order. The consummation of this tendency is already more than indicated above the horizon, when the lowest range of existence will be the standard of all, and then the chaos of organic nature will become the legitimate property of the chemists, to be by them resolved into gases and the dead materials of the earth.

Another characteristic of the times is the almost total breach of continuity between the present and the past. The terminology of science is so much altered that it is impossible to read the older works with benefit, unless after a course of study something like that requisite for learning a dead language. In

consequence, the mere anatomical value of the fathers of anatomy is not at all understood; their rich mines of observation are no longer worked, and their forgotten discoveries are now and then again discovered, with all the pains of a first attempt, by their ill-informed successors. Can anything be less human than this,—that the parents should transmit so little to the children, or rather that the children should be willing to receive so little from the parents? It exchanges the high destiny of man for the fate that attends the races of animals, in which each generation lives for itself alone, and again and again repeats the same limited series, without improvement or the possibility of evolution.

In the midst of this humiliating condition, what loud sounds do we not hear of "march of intellect" and "progress of the species,"—so many discharges from the impotent artillery of self-conceit. This indeed is the last and worst sign of a decadent science. The poor sick sufferer is delirious, and possesses for a moment superhuman strength in his own exhaustion.

The present cultivators of science boast themselves followers of Bacon in the inductive method, apparently grounding their claim on the fact, that they dwell in effects or in proximate causes to the exclusion of final causes. It is a remarkable circumstance, that each age since Bacon's time has considered itself especially as his follower, and that the present age, besides laying this unction to its soul, denies the genuineness of the Baconianism of all preceding ages. Meanwhile there can be no doubt, that if Bacon himself were to publish his works now for the first time, he would be ranked among the mesmerists, the phrenologists, and the other poor gentiles, who are banished by common consent to the far islands of the scientific world, and would be exterminated from it altogether if they were not preserved in some mysterious way,—perhaps by having the truth on their side. Bacon himself would belong to these gentiles; but would their antagonists *then* lay an exclusive claim to his philosophy? We apprehend not. The inductive method would be far from fashionable if its larger tendencies were seen, or if the scientific beliefs to which Bacon himself was led by it, could be currently reported. Would it not freeze a Royal Society to the very marrow, to be identified in any way with a

man who believed, as the great Lord Bacon did, in witchcraft, and the medicinal virtues of precious stones?

Notwithstanding the unpromising state of things in science, the natural theologians have adventured to deduce from it "the power, wisdom, and goodness of God as manifested in the creation." Truly the creation is an effluence and argument of divine wisdom. But in the present range of scientific insight, it is not seen to do more than approximate to the works of human skill. The mechanics of the watch are more wonderful to man than the mechanics of the ear or eye; the arch is the antetype of which the convex skull is but the type. Natural theology based on such science, can attribute nothing to God which does not belong in a superior degree to man. Its discoveries are not worth making, because they are so infinitely transcended by the perceptions of common sense in all nations and ages. Now Swedenborg, in his scientific works, was a natural theologian, but he began where human skill terminates, and by the application of guiding doctrines, followed the ever-expanding order of creation inwards to the point where mechanics and geometry are realized in more universal laws of wisdom and providence; and where at last the human mind itself recognizes the very source of life in its humiliation before the throne of God.

But it would be far from the present line of argument, to maintain that the moderns are performing no useful function in the "progress of the species." Such a proposition would be incompatible with what we know of the divine economy, in which human degeneracy itself is converted into a new point in the circle of uses. Nay, the moderns have their direct value; in the first place, they have enlarged the catena of observation in many departments. In the second, they have corrected innumerable minute errors in their predecessors, who were more intent upon general than particular accuracy. And thirdly and chiefly, although in this respect no credit attaches to them, they have gone so low in their enquiries, that as it is even physically impossible to go lower, so by the law of the contact of extremes a revolution may now take place, and the ascending passage be commenced, as it were from the skin to the brain, or from the lowest sphere to the highest.

It would be interesting to trace the successive stages by

which the physiology of the ancients declined into that of the moderns, to review the grounds on which great doctrines were given up, and to test the sufficiency of the reasons which were adduced for the change. The state delineated in the well-known lines—

"I do not like thee, Doctor Fell,
The reason why, I cannot tell;
But this alone I know full well,
I do not like thee, Doctor Fell,"

—this state was the moving cause of it. In short, it was a change in the human will, and not primarily in the understanding, which faculty appears to have been called upon subsequently, to confirm the new turn of the inclinations. Such at any rate we know to be the case with the doctrine of the animal spirits, which, as Glisson said, was in his time believed in "by nearly all physicians, and by all philosophers." It might have been supposed that the animal spirits were demonstrated out of existence by some beneficent genius who substituted something better in their place; at least that they fell honorably in a well-fought field of argument. No such thing; they fell by the treachery of the human heart loving the sensual sphere more than the intellectual. Is such mere waywardness as this a part of the "progress of the species?" The ancients believed in the existence of the animal spirits without pretending that they could become objects of sight. "Tam subtile sit concipiendum [fluidum hoc subtilissimum]," says Heister, ". . . ut instar lucis velocissime se diffundat; quod profecto non oculis, sed ex effectibus et phænomenis, . . . ope judicii sive mentis oculis cognoscendum. . . . Ita *aërem, animam,* et multa non *videmus,* quæ tamen ex effectibus, quemadmodum spiritus animales, esse et existere *intelligimus.*"* But the moderns reject whatever they do not see, and will credit the existence of nothing that absolutely outlies, and must in its conditions for ever outlie, the senses. It is needless to say that a state like this is based upon neither reasons nor sensations, but is purely negative or sceptical, and must be referred to sheer will without any admixture of wisdom.

We promised at the outset to speak of the relation in which

* Comp. Anat., n. 301, not. *a.*

Swedenborg's philosophy stands to the science of the day, but it will now be seen that there is no direct relation between the two, but a plenary repugnancy. For the one is order, the other is chaos: the one is concentration, the other is infinite division: the one enlarges its limits in that interior world where creation exists in all its spiritual amplitude, the other loses its limits, and its distinct life along with them, in the great vacuities of space and time: the one is a rod and staff giving the mind a practical support in the exploration of nature's fields, the other is a mist of hypotheses crawling along the ground, and making every step uncertain and perilous.

The science of the moderns tends to bury physiology more and more within the schools; that of Swedenborg will ultimately shed it abroad as a universal light which like that of the sun belongs in justness to all mankind. In this respect science is situated precisely as theology. There is no difficulty in either but what man himself induces. The whole scheme of true theology is so simple that the humblest capacity may understand it, and so coherent, that the memory may retain even its details without the slightest difficulty. So in a measure will it be with a true science. The appointed professors of the true theology must be amenable to a common knowledge thereof existing in the understandings of their flocks and congregations. So must it be at last with the professional bodies appointed to preside over a true science. In a word, under the influence of the New Church, a protestant state must come over science itself; the bible of nature must be opened to the public as well as to the professions; and the professions themselves must be content to accept their position, from standing in a clear and recognized connexion with the common sense of mankind, as brought into play upon their own subjects.

The relation in which Swedenborg stands to the philosophers may be briefly characterized. The analysis and classification of the conditions and states of the mind is a subject which he has only touched on incidentally in the "Animal Kingdom." He maintains that the influx of the soul into the body is truly synthetic, or *a priori ad posteriora*, but that the instruction and information of the rational mind is necessarily analytic, or *a posteriori ad priora*; not that the senses generate the mind,

but that they supply it with materials, and externally excite it to activity; the soul similarly exciting it internally. With respect to that mentalism which has been introduced since Swedenborg's time by Kant and his followers, the writings of Swedenborg distinctly involve it, but then our author adds to its forms life and substance, and displays a world coördinate with each plane of the human faculties, without which man would not exist in nature. By virtue of this, what are mere abstract categories and ideas in the one, are organic causes in the other, (Swedenborg says, "all causes must be formed organically,") and the mind is allied to the body through the whole scale of its ascent. But there is one department of metaphysics or ontology which finds no countenance in Swedenborg; viz., the two schemes of materialism, and immaterialism, or as it is falsely called, spiritualism, as opposed to, and opposing, each other. The controversy between these two he declares to be "a battle of words," a play of "shadowy sophisms," a "game at chess in the high city of literature;" and he refers the whole misunderstanding to ignorance of the doctrines of forms and degrees.* For this war respecting the substance of which things are made, tends to divert the mind from the successive order of nature, and to plunge it at one leap in the occult; consequently to induce it to omit all the series of forms that intermediate between the body and the soul. The words mind and matter in this case stand for two substances under one form, and it is not easy to see how the one can be preferable to the other, or how thought can be influenced by either of them. As systems of causation therefore, the rule of use protests against them both. The main argument of Bishop Berkeley, that his hypothesis causes no difference to our sensations, must be admitted, and it is conclusive against immaterialism. Why introduce an element that confessedly plays no part in our affairs?† Both these

* See the "Economy of the Animal Kingdom," tr. ii., n. 311; and the "Worship and Love of God," n. 53, note (p).

† If it be alleged that immaterialism produces philosophical results, and is capable of being expanded into a system, we reply to this, that wherever such results appear to follow it, they arise in reality from the tacit intermingling of some organic element of thought in the premises, the presence of which element is not perceived. It would be easy to illustrate this by a criticism of any of the philosophical and religious consequences which are supposed to flow from immaterialism, and to prove

schemes are essentially controversial or negative, and if either of them could be substracted, the other would no longer be capable of an expression. Both of them tacitly deny the order of nature, and therefore they can never minister at the altar of true science. Matter and substance may be opposites, but this has nothing to do with the question of the existence of matter. The mind is a substance, but this likewise in no way touches the existence of matter. The question of the existence of matter is perfectly distinct from the question of its substance. What then is the definition of a substance? It is evident that a substance is the ground of a particular existence; and equally so, that the only ground for which anything exists is the end or use that it will subserve in the creation. The particular end or use, then, of each thing is its substance. But ends and uses in themselves are spiritual. In order, therefore, that this end or use may institute a series in nature, it must put on a natural form; and the first form that it so assumes, the form of the first degree, is the substance or unit of the whole series, as

that those consequences are not the fruits of the immaterialism, but of other grounds coexisting with it in the mind. But the demonstration would carry us beyond the design of the present remarks. With respect to substance, it may be expedient to observe, that the word is commonly used in two meanings, both of which are true, and must concur to a complete idea of the thing. Firstly, it is used in a universal, generative and active sense, as the elemental ground of matter, and as the spiritual ground of the natural world, in which partial sense, substance is spiritual, and its operation purely synthetic. Secondly, it is used in a general, formative, and passive sense, as the complex, continent, and basis of interiors and universals, in which partial sense, substance is material, and its operation purely separative or analytic. But the complete idea of substance is the result of the union of these two senses; in other words, of the ordinary notions of both substance and form; which although two elements in thought, are not two in reality, but "distinctly one." Swedenborg clearly shows both in his philosophical and religious works, (which indeed are perfectly at one on this subject,) that we must take a bodily as well as a mental view of substance. It may be sufficient to cite the following passage from his work on "Heaven and Hell." "Man," says he, "cannot exercise thought and will at all, unless there be a subject, which is a substance, from and in which he exerts those faculties. Whatever is imagined to exist, and yet to be destitute of a substantial subject, is nothing at all. This may be known from the fact, that man cannot see without an organ as the subject of sight, nor hear without an organ as the subject of hearing. Without such organs, sight and hearing are nothing, and have no existence. It is the same with thought, which is internal sight, and with apprehension, which is internal hearing: unless these existed in, and from, *substances, which are organic forms*, . . . they could not exist at all," &c. (n. 434.)

being all in all throughout the subsequent degrees: it is the universal of the series, as being, by virtue of the properties of its form, universally present, potent, active, &c., in the entire progression of the thing that it constitutes. It is the relation that this unit bears to order, degrees, and series, that makes it into a substance and not into an accident. Hence it is order that determines substance, and hence too every substance is an organic form, as being the initiament of all the forms of its series. Mental admissions of substance which do not involve forms analogous to those of the natural creation, are mere terms without ideas: views of mind, thought or affection, which contemplate these subjects otherwise than as prototypes of the human body, are vacant of meaning: metaphysics without they rest upon the order of physics, are a soul without a body, and belong neither to this world nor to the next. Whatever deflects the understanding from order, as the question of questions, deflects it equally from both mind and matter, and consigns it proportionably to the "shadowy sophisms" of materialism or immaterialism. In the highest sense God is the only substance, and yet in a true sense, each degree is a substance to that proximately below it. All finite differences are in reality variations of form determined by uses in their order. Each degree involves the repetition in itself of all the three degrees, of end, cause, and effect; and hence nature itself is full of substances, —of bodies possessing real trine dimension,—and matter also involves as many substances as it has distinct forms. If we suppose that nature is a mere surface, we manifestly indispose the mind for admitting a doctrine of forms, consequently we detain it in the last degree, and in the lowest plane of imagery, and when this is the case we must look upon science as something which exists by courtesy, a record of appearances and superficialities which are only presented to us to be negated. Thus the spiritual violates the natural, instead of leaning upon it, as a house upon its foundation. But let no logic disturb our foundations thus: the principle of use, and the test of results, furnish a more conclusive experiment of ideas than any syllogistic process; for they scrutinize the end, and not only the means. This principle and test declare to us, that in the investigation of nature, we are to keep our minds in the idea of

order, as manifested in successive degrees of forms, forces, operations and uses, and that then we are legitimately studying the nature of substance in the only meaning that it has for finite beings. Other substance than this is a figment, which is rendered necessary by nothing in the theory of causation, because it will legitimately account for nothing. It has no function in the new state of things, but belongs essentially to the scholasticism of a past church.

Having now briefly indicated the relation between Swedenborg's science and philosophy and that of his own and the present time, we have still to speak of a few points which more particularly belong to the Work before us.

The reader may probably be led to enquire, how far the "Animal Kingdom" embodies doctrines which were current at Swedenborg's day, and how far its deductions are peculiar to our author. To this it may be answered, that many doctrines to be met with in the Work are by no means peculiar to Swedenborg, but were the common intellectual property of his contemporaries and predecessors. We have seen that a host of writers held the doctrine of the animal spirits. It was also no uncommon belief that they were elaborated by the cortical substances of the brain, and circulated through the nerves. Vieussens held that there were distinct degrees of them. Brunn propounded the same doctrine as Swedenborg respecting the pituitary gland; and numerous instances to the same effect might readily be adduced from other writers. Perhaps the best means to be certified on this head, will be by the perusal of Boerhaave's "Institutiones Medicæ,"—a work where the theories of many ages are condensed into an eclectic system. It appears as though Swedenborg freely availed himself of the treasures that were accumulated around him and before him, and was altogether destitute of that passion for originality which has been the besetting sin of so many of the learned. He distinctly states that he has relied upon his own experience to but a small extent, and that he has deemed it wiser, for the most part, to "borrow" from others.* So also where he found true doctrines and deductions,—these likewise he borrowed, and

* "Economy of the Animal Kingdom," tr. i., n. 18.

this, with generously grateful acknowledgment. But what he really brought to the task were those great principles of order to which we have before alluded, and which touched nothing that they did not universalize and adorn; nay, which built the materials of experience and the deductions of reason into a glorious palace that truths could inhabit. It is as the architect of this edifice that Swedenborg is to be viewed, and his merits are to be sought for not so much in its separate stones, as in the grand harmonies and colossal proportions of the whole.

After this statement it is scarcely necessary to observe, that Swedenborg is not to be resorted to as an authority for anatomical facts. It is said, indeed, that he has made various discoveries in anatomy, and the canal named the "foramen of Monro" is instanced amoug these.* Supposing that it were so, it would be dishonoring Swedenborg to lay any stress upon a circumstance so trivial. Whoever discovered this foramen was most probably led to it by the lucky slip of a probe. But other claims are made for our author by his injudicious friends. It is said that he anticipated some of the most valuable novelties of more recent date, such as the phrenological doctrine of the great Gall, and the newly-practised art of animal magnetism. This is not quite fair: let every benefactor to mankind have his own honorable wreath, nor let one leaf be stolen from it for the already laureled brow of Swedenborg. True it is that all these things, and many more, lie *in ovo* in the universal principles made known through him, but they were not developed by him in that order which constitutes all their novelty, and in fact their distinct existence. For in the first place it is impossible for the human mind to anticipate facts; these must always be learnt by the senses: and secondly, Swedenborg was too much a man of business to turn aside from the direct means to his end, or to attempt to develop anything beyond those means. His philosophy is the high road from the natural world to the spiritual, and of course has innumerable lateral branches leading to the several fair regions of human knowledge: but through none of these by-ways had Swedenborg time to travel: nay, could he have done so, there is nothing to shew that he

* See "Animal Kingdom," vol. I., p. 250, n. 190, note (*r*).

would there have discovered what his successors have done. He had his mission, and they have theirs. His views are at harmony with all that is new and true, simply because they are universal, but in no fair sense do they anticipate, much less supersede, the scientific peculium of the present century. Swedenborg, therefore, is not to be regarded as an Aristotle governing the human mind, and indisposing it to the instruction designed to be gained from nature; but as a propounder of principles the result of analysis, and of a method that is to excite us to a perpetual study in the field of effects, as a condition of the progress of science.

The anatomical knowledge possessed by Swedenborg was undoubtedly very extensive. He appears to have studied more by plates than by actual dissection, as almost any one would naturally do who had in view the same end as himself. This will be regarded as an unpardonable vice by the physiologists. But why should the knowledge of the human frame be limited to the dissecting-room? Why should it be the appendage of one craft, and not an inheritance of universal humanity? Why should the truths of the body be the exclusive property of the physicians, any more than the truths of the soul the exclusive property of the clergy? Have we not all souls, and have we not all bodies? Now good and accurate plates, corrected and generalized during several ages, are far more valuable and available as a basis of general education, such as the New Church must ultimately desire, than either dissections or preparations. It is something that they carry none of the adjuncts of death, disease, or putrefaction; that they do not hinder the mind from recollecting that life and motion are the import and lesson of the body. It is something that they may be placed within the reach of all. Swedenborg has set the example of what may be done by studying them, and his readers must follow the same course if they wish to profit by his instructions.*

The professional reader of the "Animal Kingdom" will not fail to discover that the author has fallen into various anatomical errors of minor importance, and that there are occasion-

* The beautiful little book by Erasmus Wilson, entitled "The Anatomist's Vade Mecum," may be recommended to the readers of the "Animal Kingdom," for the number of excellent plates that it contains.

ally marks of haste in his performance. This may be conceded without in any degree detracting from the character of the work. These errors do not involve matters of principle. The course which Swedenborg adopted, of founding his theory upon general experience, and of only resorting to particular facts as confirmations, so equilibrates and compensates all misstatements of the kind, that they may be rejected from the result as unimportant. To dwell upon them as serious, and still more to make the merit of the theory hinge upon them, is worthy only of a "minute philosopher," who has some low rule whereby to judge a truth, instead of the law of use. Such unhappily was the rule adopted by the reviewer of the "Animal Kingdom" in the "Acta Eruditorum Lipsiensia" (1747, pp. 507—514): the book was despised by this critic because Swedenborg had committed an error in describing the muscles of the tongue, and because he had cited the plates of Bidloo and Verheyen, which Heister and Morgagni had then made it a fashion to disparage; and for other equally inconclusive reasons. All they amounted to was, that Swedenborg had not accomplished the reviewer's end, however thoroughly he had performed his own.

But fortunately such criticisms are never decisive; a single truth can outlive ten thousand of them. The "Animal Kingdom" appeals to the world at this time, a hundred years since the publication of the original, as a new production, having all the claims of an unjudged book upon our regards. For during that hundred years not a single writer has appeared in the learned world, who has in the slightest degree comprehended its design, or mastered its principles and details. The reviewer to whom we have more than once alluded, judged it by a standard which was suited only to an anatomical manual and text-book. Haller bestowed a few words upon it in his invaluable "Bibliotheca Anatomica," but he knew nothing of Swedenborg's views; and his notice of the "Economy of the Animal Kingdom," contains errors too numerous not to invalidate his censure, had he bestowed it, which however he has not done directly. Sprengel, in his "History of Medicine," has offered a few lines upon the work, but these merely of a bibliographical import. The past therefore has found no fault in it, and it comes before the reader with an uninjured character, and de-

mands as a good, true, and useful book to be taken into his service, and to receive a full trial at his hands. The modern physiologists having no theory of their own, have no reference to it, nor until they quit their present ground can they be allowed to have an opinion on the subject. Their censure would not be more relevant than would the opposition of a Red Indian to the problems of the mathematics.

But it may fairly be asked, what are the prospects that the "Animal Kingdom," and the scientific works of Swedenborg generally, will be received at this day, when they refer to an order of facts almost forgotten, when they involve a scientific terminology which has become partially obsolete, and especially when it is considered that there never perhaps was an age so well satisfied with itself and its own achievements as the present one? Their prospects in the high places of science are not indeed encouraging: it would be vain to build up hopes in that quarter, or to address expostulations to it. A commission of any Royal Academy in christendom would soon decide our claims in the negative. But fortunately there are abundant signs of a breaking up. The scientific world, and specifically the medical world, which is always the highest exponent of the state of science, is in a state of intestine revolution; nay, what is saying much, it is nearly as full of dissension as the church itself. It would be exceedingly unpalatable to dwell upon its divisions, to specify the sects which have separated from the maternal body, and to shew the irreconcilable nature of the differences that subsist between orthodox medicine and her refractory children. The future historian, standing upon the grave of once venerated institutions, may do this with impartiality, and not without a feeling of pity. Meanwhile it is our privilege to rejoice, that amid the decadence of science new ground is being broken, and new spirits raised up, to some of whom the new truth may be accommodated and delightful.

We use the phrase "new truth," although the works which contain it have been buried in the dust for a whole century; but in so doing we simply allude to the principles involved in those works. The confirmatory facts by which these principles were brought into relation with the science of Swedenborg's day, may doubtless from time to time be superseded by better

attestations: particular facts are but the crutches of a true theory, and are not strictly speaking its basis; for the basis itself is spiritual, since it is the order and tenor of effects that form it, and not the matter. The principles themselves are eternal truths,—the same yesterday, to-day, and for ever. They are not attached for more than a time, or for any end but necessity of use, to any one range of facts, or to the books of any one author,—no, not even of a Swedenborg.

There are cycles in all things, and even now there are some indications of a revival of medical learning. The weakness of the present state of things is perceived by those who have no appreciation of its barrenness; the temper of the public is an unmistakable demonstration to this effect. Hence many begin to revert to the past, and laying aside for a moment the vociferation of "march of intellect" and "progress of the species," they are content to march and progress, like the crab, backwards, and to claim Hippocrates and Galen and Sydenham as their fathers. This is at any rate so far good, that it shews how a forgotten range of facts and an antiquated terminology may be reacquired as soon as there is a sufficient motive: nay, it nourishes the hope, that under the pressure from without, the large body of dependents, if not the feudal lords of science, may come to even greater and more unexpected results than these. Who shall say that they may not ultimately see that it is their interest, as practitioners of medicine, to deposit their cloke of mystifications, to bring to market something which is intelligible and useful to humanity, to go wherever truth leads them, even though that truth be "stranger than fiction," and to come to our Swedenborg in his double character, and acknowledge with humble thankfulness that a greater than Hippocrates is here,—a man who has married practice to theory, who has dissected the living body without destroying it, and has so opened the sciences of anatomy and physiology, that they must sooner or later become branches of *human* education, in which case the medical profession will have a solid basis in the social world, and be as a golden crown of wisdom and practice resting securely upon the correct knowledge and common sense of mankind.

To all those who are in possession of truths which are not

recognized, or are rejected, by the systems of the day, the writings of Swedenborg may be perfectly invaluable. Those writings will prevent them from being dependent, in any department of reason, upon the old state of science. They will furnish a high rallying point where a number of such distinct truths may be combined, and derive that strength which is the result of union, and especially of the union of truths. They will put weapons of offence and defence in the hands of causes which are now repressed almost into nothingness, and give power to those which are strong in spirit, yet weak in body. They will add force to faith, and sustain the earnest soul through the day of small things, and meanwhile yield it a peaceful delight prophetic of a glorious future. To all such persons these writings ought to be as glad tidings, and should be received with hearty thankfulness, and a determination to lose no time in converting them to use.

But it is on the New Church itself that Swedenborg's scientific works have the highest claim. They were written, indeed, to convince the sceptic, yet perhaps their chief end may be to confirm the believer. They disclose the intellectual use of nature, as being a theatre of instruction where man may learn the highest truths in the lowest form, and from which he may mount upwards, on the ladder of divine order, until the intellect merges in the moral sphere. They proclaim that in this course of true instruction there is nothing to be unlearnt, either in this life or in that which is to come, but that our limits are to be successively enlarged, and all that is real and positive ever carried forwards into the proximately succeeding state. For these works are thoroughly congruous with the theology of the New Church. The order which they shew to exist in nature, is the very mirror of the order that reigns in the spiritual world. They mark the successive stages through which Swedenborg was led by the Divine Providence, until he was capable of that interior state in which his spiritual eyes were opened, and the inner world disclosed to his view; and as they were therefore the means, so were they in unison with the end. The doctrines which they set forth respecting the human body are reiterated with scarcely an omission in his theological treatises, and particularly in his "Arcana Cœlestia," where they serve as the

ground-work of his stupendous descriptions of the life of man after death, when he is associated with his like, according to the laws of order and degrees, and if he be capable of it, becomes a part of the grand human form of heaven. It is therefore at once edifying and delightful to examine the scientific evolution of those doctrines in the "Animal Kingdom," and to observe how wonderfully coherent they are, and how firm they stand in nature. At the same time, far be it from us to admit, that Swedenborg's theology was the outgrowth of his science. This has been stated to be the case, and it is an assertion easily made, a proposition which the sceptic will be too ready to conceive. But we give it a direct negative: it is the offspring of a double ignorance,—of an ignorance of both the premises. Those who are best acquainted with the writings of Swedenborg know full well that it has not a glimmer of probability to support it.

Nevertheless it may be confidently affirmed, that it is impossible to affix a meaning to much that Swedenborg has said of the human body in his theological writings, without a study of his scientific works. In this respect the former presuppose the latter, as containing a body of elucidations that cannot be obtained from the views of any other physiologist.

But these works not only support and elucidate Swedenborg's theological writings, but they also afford the members of the New Church an opportunity of descending from the spiritual sphere into the natural, and there gathering confirmations from the broad field of creation. In proportion as this is rightly done, or done for spiritual ends, there will be a regeneration of the sciences, and the ascending or analytic method will become subservient to the influx of spiritual power and truth from above. The order of nature will be more and more seen to be at one with the order of heaven. The sciences through which nature is viewed in different aspects, will become easy of comprehension and recollection, because all their details will be ranged on the electric spirals of order. The organic sciences especially will be schools in which the great lesson of society is learnt, and the laws of government and intercourse represented. The human imagination will be limited by the truth, and will admit that all that outlies its sphere, is a monstrosity, and an

outrage against the universal principles of art; and that without rational truth there can, at this day, be no true art, as there can be no heroic action. The understanding will no longer love the occult, or dwell in quiddities and logical formulas, but in the recognition of ends and uses in substantial forms. Man will see the omnipresence of God in nature, because he will contemplate a moving order, perpetually tending from ends to ends, and thus involving an infinite intelligence and love in every point of its progression. There will no longer be faith alone, nor charity alone, nor works alone. The natural world will not be divorced from the spiritual, nor the body from the soul; for there will be no hostility between the different faculties of the mind, but the spiritual man will rest on the rational, and the rational on the sensual, which last will then become the enduring basis of the heavenly, and the ultimate theatre of its life and fructification. "In that day there shall be a highway out of Egypt to Assyria, and the Assyrian shall come into Egypt, and the Egyptian into Assyria, and the Egyptians shall serve with the Assyrians. In that day Israel shall be the third with Egypt and with Assyria, even a blessing in the midst of the land."*

But until this prophecy is accomplished, science must be dead. For the Egypt, Assyria, and Israel of the Word, are not places, lying under a particular latitude or confined to one planet, for the divine truth is omnipresent, and transcends the conditions of space and time; but they are general states within every man that is born into the world. The Egypt of divine truth is his scientific mind; the Assyria is his rational mind; and the Israel, his spiritual; and the prophecy here describes the true order of the influx and circulation of mental states and principles, in either an individual, a society, or the human race at large. This is the order to which we believe power will ultimately be given by Him who has all power in heaven and on earth. For we know that until it is established, opinion must be as the shifting sand; human systems must be so mortal that the mere flux of time is sufficient to destroy them; the scientific state of each age must be at the mercy of any strong man

* Isaiah xix. 23, 24.

with an energetic will and an equal faculty of persuasion; since without a permanent reference to true order, intellectual feats can be measured by no standard but daring and determination. But a better time is at hand, and a better state than man deserves, or than he himself could originate. The new era has commenced already. The truths of a New Church have been revealed in the writings of Swedenborg; and in those truths, and those truths alone, may science drink of the waters of immortality.

THE ANIMAL KINGDOM,

CONSIDERED

ANATOMICALLY, PHYSICALLY, AND PHILOSOPHICALLY.

BY

EMANUEL SWEDENBORG,

LATE MEMBER OF THE HOUSE OF NOBLES IN THE ROYAL DIET OF SWEDEN,
ASSESSOR OF THE ROYAL METALLIC COLLEGE OF SWEDEN,
FELLOW OF THE ROYAL ACADEMY OF SCIENCES OF UPSALA, AND OF THE ROYAL ACADEMY OF SCIENCES OF STOCKHOLM,
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TRANSLATED FROM THE LATIN

BY

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